SILK THROWING

AND

WASTE SILK SPINNING

BY

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WITH ONE HUNDRED AND TWENTY-ONE ILLUSTRATIONS

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PREFACE.

A DESIRE having been expressed in many quarters for a book dealing with silk yarns and the machinery and processes necessary to convert the fine fibre of the silkworm into a weavable thread, the author arranged with the proprietors of the well-known journal, the *Textile Manufacturer*, to publish in that monthly a series of articles dealing with these subjects.

These articles revised, and further illustrated, form the contents of this book, and it is hoped that this work will be a handy reference volume, and of great assistance to manufacturers of textile fibres who may desire to use silk in their fabrics in some of its many forms; and to teachers and students who wish to have a knowledge of the Queen of Textile Fibres.

The author has endeavoured to concisely describe the principles of Silk Throwing and Waste Silk Spinning, as exemplified in the machinery employed in these two industries, most of the illustrations being made in section, or diagrammatically, to facilitate their comprehension by a student ignorant of the trades concerned; and machinery calculations have been purposely kept out in order not to divert attention from the main principle of each process.

The author, who has personally had many years' experience in the silk trade, takes this opportunity of thanking his many friends, machinists, managers of works, foremen, and workmen who have given, in their respective capacities, invaluable assistance in the preparation of this book.

H. R.

December, 1920.

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GLOSSARY.

Bave.—The united brins or strands spun by the silkworm.

Bookboard.—Two thin boards of wood hinged together like a book in which to remove a strip of silk from filling engine, comb, and to hold the strip of silk whilst undergoing the dressing operation.

Books.—A certain number of heads or hanks of raw silk bound together by bands in the form of an oblong book. Twelve books make a bale of raw silk.

Brin.—The two strands emitted by the worm when spinning its cocoon.

Carrier.—Small rollers acting as supports to rovings between back and front rollers of drawing machinery, roving frames, and spinning frames.

Chops.—The qualities or names under which raw and waste silk is sold.

Cleaner waste.—The waste made during the cleansing of wound nett silk from foul pieces and "gouty" places.

Cocoon.—The silken covering of the pupæ. A double cocoon indicates that two worms have spun side by side, whilst a pierced cocoon means that the moth has emerged or "pierced" the cocoon.

Degumming.—The operations of freeing, wholly or in part, the silk thread from its covering of sericin or gum.

Deniering.—The dividing of reeled nett silk into counts or sizes.

Discharging.—The operations necessary to boil silk waste and silk yarn *free* from gum.

Draft.—The drawing out of one or more ends of sliver or roving into a thinner end.

Drafts.—The name given to dressed silk, the term "first draft" denoting the longest length of fibre possible to obtain out of any given quality of waste, the second draft being the second longest length of fibre, and so on. The lengths are usually denoted as follows :—

	Long drafts.				Shorts.		
English method	1st drafts.	2nd drafts.	3rd drafts.	4th drafts.	5th drafts.	6th drafts.	7th drafts.
Foreign method	A	B	C	1st drafts.	2nd drafts.	3rd drafts.	4th drafts.

Drawing.—The preparation of dressed silk previous to spinning—that is, all the processes after dressing, carding, combing, up to the spinning frame.

Dressing.—The separation of the different lengths of fibre.

Fibroin.—The pure silk thread spun by the worm.

Gouty.—A thread having on it thick, rough places.

Graine.—The egg of the silk moth.

Gum.—The hard gum-like covering of the silk thread (fibroin). It is also called "sericin" and "bast".

Hank.—A skein of thread of a fixed length.

Long spun.—A term used to indicate that the yarn spun from silk waste is spun from silk drafts which have not been "cut" after dressing, and in contradistinction to short spun, which used to imply that the dressed silk was cut into short lengths prior to carding, drawing, and spinning, but is now often applied to waste silk yarn of short fibres which has been carded.

Nett silk.—Sometimes spelt "neat silk". A term used in contradistinction to "spun silk," really being a name applied to all silks produced by the silk throwster.

No-throw.—A thread composed of filaments of raw silk wound together with a very small amount of twist.

Noil.—The short silk which has been separated from the long fibres in the dressing operations, and also the short silk combed out of the noil from the dressing frame; the noil from the last-named machine being called "long noil," and the noil from the comb the "exhaust noil".

Organzine.—Nett silk used as warp.

Ratch.—The distance between back and front rollers in any drawing or spinning machine.

Raw silk.—The thread produced by cocoon reeler and sold in form of skeins, each thread composed of a number of filaments.

Rawy thread.—A thread showing thin places. In raw silk this is caused by bad reeling, in spun silk by uneven drawing, or too much draft in the spinning.

Schappe.—Refers to a spun yarn which has been spun from waste which has *not* been fully discharged or degummed.

Schapping.—The fermentation of silk waste at low temperatures to soften the gum or bast (sericin) on the silk fibre.

Scroop.—The rustling sound given out by silk yarns and fabrics, and which is caused by such yarns or materials having been passed through an acid bath.

Sericin.—The "soluble by water" portion of the fibre spun by the silk-worm. *See* Gum.

Short spinning.—The processes necessary to spin yarn made from fibres of dressed silk which have been cut into short lengths. The term is applied also to yarn spun from short fibres of silk, which, preparatory to spinning, have been carded and drawn on rotary or roller drawing frames.

Singles.—Raw silk which has received a slight twist in the spinning frame, if the yarn is required for weft purposes, and a hard twist if required for warp purposes.

Sliver.—The ribbon-like silk, delivered by any drawing frame, without any twist in it.

Slubbing.—An attenuated sliver, but delivered on to a bobbin and with twist in, thus making a soft thick thread of silk, two or more of which bobbins of silk are placed behind the roving frame, and in that machine still further reduced in size or count.

Spinning.—The operation necessary to twist together fibres or threads of nett silk, or the act of putting twist into a thread on a spinning mill in silk throwing. In waste spinning and the spinning of all textile fibres, except nett silk, this term means the operation of drawing or drafting out a predetermined length of yarn from a roving, and on the same machine puttiug twist into the attenuated end or thread.

Spun silk.—A yarn composed of fibres of silk, which fibres have been dressed from waste silk.

Throwing.—The operations necessary to convert raw silk into any desired size or count suitable for manufacturing.

Thrown silk.—A yarn composed of fibres of silk, each fibre or filament being the longest length possible to obtain from a cocoon, and such fibres of reeled silk having been "thrown," meaning wound together and twist put on the thread in a silk-throwing establishment.

Tram.—Nett silk used as weft.

Twist.—The number of turns per inch in any thread.

Waste silk.—Raw silk which will not reel and waste made in the various operations of silk throwing. Really tangled messes of silk which have to be cut or dressed into lengths before they can be spun. *See* Spun silk.

Winder waste.—The waste made during process of winding raw silk on to a bobbin. Known also as "fine waste," because it is usually a fine thin place which will not bear the tension of winding, and has therefore to be taken out by the winding frame attendant.

SILK THROWING AND WASTE SILK SPINNING.

INTRODUCTION.

Although much information is obtainable in this country regarding the weaving of silk goods, very little seems to be understood about the earlier processes of silk working. The terms raw, waste, thrown, spun, or schappe silk are very vague even to the ordinary manufacturer, though he may use silk in conjunction with his cotton or worsted goods, and by others the terms are still less understood. The English silk industry has long been in a declining condition, although anyone looking in the principal drapers' windows cannot but be impressed by the growing popularity of the fibre. It is lamentable to have to admit that instead of progressing, as is the case with most of our other textile fabrics, silk has become less and less an English industry, and there appears the chance of it being entirely overshadowed by continental competitors. Some few years ago silk manufacturing was a most profitable industry in this country; but unfortunately, when import tariffs were removed and foreign competition began to be felt, there was a singular lack of energy displayed, and little attempt was made to keep abreast of the times. No trade has suffered more from conservatism; machines have not been modernised, and many in use at the present time have been in existence for a generation. Some manufacturers are still clamouring for protection as the only means of saving the industry, although the possibility of combating foreign competition is demonstrated by the very few energetic firms who have proved themselves capable of competing against all comers in the open market.

Of late years some cotton and worsted manufacturers have turned their attention to silk, and instead of looking to Macclesfield and Spitalfields as the centres of the British silk weaving industry, we now turn to Bradford and district, or to Glasgow, whilst Manchester and the neighbouring East Lancashire towns get through a fair amount of spun silk for shirtings, zephyrs, striped goods, etc.; and although there probably never were fewer who could strictly call themselves "silk manufacturers," it is likely there never were more users of silk, even in the palmy days of the trade. This new life tends to bring the trade into line with other textile industries, and as cotton and worsted manufacturers find there are no great difficulties in the manipulation of silk, the number is likely to increase rather than diminish.

Of the two branches, spinning and throwing, the former, as applied to the treatment and preparation of so-called waste silk, is by far the more important in this country; for while the latter has been a declining trade since the "eighties," there is to-day in England waste silk machinery capable of turning out more spun silk yarn than ever before; so in the gloomy picture of the decline of the silk trade it is pleasant to be able to record one branch which has even managed to hold its own. Throwing, as one of the three distinct sections into which the English silk industry is divided,—namely, throwing, spinning, and manufacturing,—seems to be the branch in which we, as a nation, have failed all together to keep pace with continental throwsters. Improvements in machinery can be traced to American and continental sources, but they have not been generally adopted by English throwsters.

There is a large field open for our manufacturers, if they could and would cater better for the home market. At one time silk was looked upon as a luxury, but now, owing principally to the fact that a use has been found for waste silk which formerly was of little commercial value, its use as an article of adornment is practically universal. When it is borne in mind that for every 1 lb. of raw silk produced there is about $1\frac{1}{6}$ lb. of unreelable silk remaining, and which, prior to the invention of silk spinning, was almost valueless, it will be at once recognised that there was a great possibility before an industry which would be able to use up this vast accumulation of waste. Hitherto no work has been written showing the whole history of the silk from worm to thread, and only very brief and erroneous references can be found on the spinning of silk waste. A great deal of the machinery used is common to other spinning industries, and where that is the case it has not been deemed necessary to go into any great detail. On the other hand, some processes are peculiar to silk, and these have been fully described. In no case has it been thought advisable to enter into any machinery calculations, such as the method of finding the draft wheels, change wheels, etc., all of which calculations can be got from machinists, and have been published in many text-books.

CHAPTER I.

THE SILKWORM—EGG-HATCHING.

The silkworm.—Almost every country seems to have some kind of silk-producing insect, but we generally turn to China, Japan, Italy, and Southern France as the only countries where the silkworm—which is the chief producer of industrial silk—can be successfully reared. This is a mistake, for in our own country, without the aid of artificial means, silkworms have been reared from the egg. Splendid specimens of moths have been obtained, and experts who have studied the subject, and who have for years cultivated the silkworm, are of opinion that quite as good silk can be produced here as in any other country. The reason why this is not an English industry is that labour is too expensive as compared with native labour in China and Japan and that of the peasants in France and Italy. It has, however, been proved beyond a doubt that the silkworm can be reared here just as prolifically as on the Continent, and there are worms in England to-day which have been bred from stock introduced very many years ago, and still the moths show no signs of degenerating nor does the silk appear to have become any worse. The eggs, or "graine," of the silk moth vary in size, according to the family to which they belong, but generally speaking they are about the size of a pin head, and so hard that a person might stand on them without breaking them. If stored in a cold place the eggs can be kept for almost any length of time, but if put in a fairly warm room the eggs can be hatched pretty quicky, although it is always well not to force them too much. Care should be taken that the worms do not appear before the mulberry is in leaf, or whatever food it may be intended to feed them on is quite ready.

After hatching, the worm begins at once to feed, and is most voracious, doing nothing but eat for from three to five weeks, when it is full grown, having in the meantime cast its skin no less than three or four times.

Spinning cocoon.—Fig. 1 shows the worm commencing

FIG. 1.—Silkworm.

to spin its cocoon, which it starts when full grown. The thread, which is secreted in two glands near the head, comes from the worm's underlip in two strands, or brins, which unite, and are then termed "bave." Some species attach themselves to the twig of a tree (as will be seen from the illustration) before commencing to spin, whilst other kinds secrete themselves between two or three leaves, and then envelop themselves in a cocoon of silk.

When the cocoon stage is reached, the worm is in what is called the pupa, or chrysalides state, and thus it remains through the winter. At the approach of the warm weather it gives out a kind of moisture to soften the silk at one end of the cocoon, then begins eating or pushing its way out, and soon what appeared months before an ugly-looking caterpillar bursts forth a winged creation—a beautiful moth, as great a transformation as man can imagine. It is only when the moth is required for breeding purposes or preserving as a specimen that it is allowed to pierce the cocoon, as immediately the silk is thus broken it is unreelable, and the pierced cocoons are only fit for waste-spinning purposes.

Sericin—Fibroin.—As the fluid thread is produced by the silkworm it is coated with a kind of varnish known as "gum" or "sericin," which becomes hard in a few days after the worm has completed its cocoon. This gum will dissolve in water, but the thread or "fibroin" itself is insoluble in water, although the chemical composition of each is very similar, as will be seen from the following analysis. The percentages are only given approximately :—

Fibroin.		Sericin.
49 per cent.	Carbon	42½ per cent.
6¼ ,,	Hydrogen	6 ,,
19½ ,,	Nitrogen	16½ ,,
25¼ ,,	Oxygen	35 ,,

It is also interesting to compare the composition of the worm itself with that of the mulberry leaf :—

Dried Worms.		Leaves.
48 per cent.	Carbon	44 per cent.
7 ,,	Hydrogen	6 ,,
10 ,,	Nitrogen	3 ,,
26 ,,	Oxygen	35 ,,
9 ,,	Mineral matter	12 ,,

Varieties of moth.—There are hundreds of different varieties of silk moths, family *Bombycidæ*, but the best known and most profilic is the genus *Bombyx*, which includes *Bombyx mori*, the typical Chinese silk moth, which produces the best silks of China, Italy, and France.

In Fig. 2 is shown the worm or larvæ A, the cocoon B, the male moth C, and the female moth D, of the *Bombyx mori*. As will be seen from these, the cocoon is very small—about the size of a pigeon's egg—but it is very compact. All cocoons produced by the *Bombyx* are reelable, and are termed closed cocoons — *i.e.* the thread covers the ends of the cocoon without any apparent break, whereas some species produce an open cocoon—*i.e.* a cocoon with what appears an opening in the outer covering of silk at the end, from which the moth would emerge. Some, but not all, of the so-called opened cocoons are reelable.

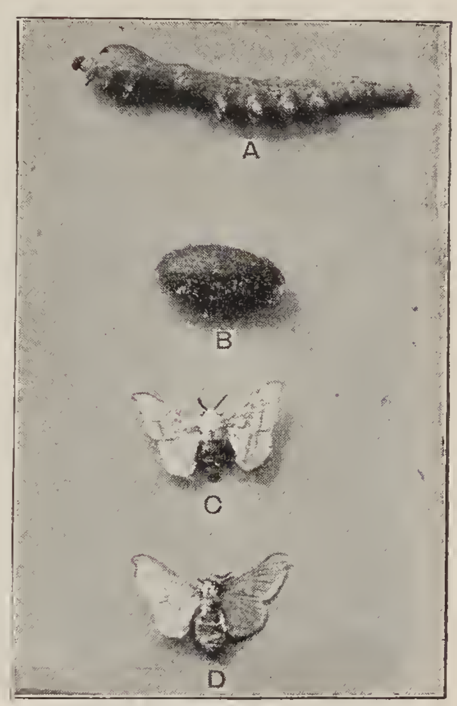


FIG. 2.—*Bombyx mori*, larvæ, cocoon, moth.

The composition of the *Bombyx mori* silk is as follows :—

Water	12·50	per cent.
Fatty and resinous	0·70	,,
Mineral	1·12	,,
Gum	22·58	,,
Fibroin	63·10	,,

The food of this particular worm is the leaf of the white mulberry tree (*Morus alba*), and the fear of frosts in the early spring on the Continent is not so much on account of the damage it will do to the worms as the fear lest it will nip the budding mulberry trees, and so delay the foliage that the eggs may be hatched before there is food for the young worms. The frost scare is often made use of in the early part of spring by speculators endeavouring to run up prices of raw silks. They give out, that owing to frost the mulberry will be delayed, and the young worms, having no food, will die, and hence there will be a scarcity of silk. The mulberry is a rare tree in this country, and lettuce and dandelion have been found good substitutes on which to feed the worm, but there is nothing to equal the natural food of the silkworm.

The next best-known group of silkworms is the tussah (tasar, tussar, tussore), of which the *Antherea mylitta* is the principal. Fig. 3 shows the cocoon at A, the male moth at B, and the female at C. (Figs. 2, 3, 4, and 5 are reduced to half the actual linear size of the insect, etc.)

The *Mylitta* spins a much larger cocoon, and is in every respect a larger worm than the *Bombyx*. It thrives in India and China, and although there is a considerable difference in the texture of the China tussah and the Indian variety, the latter having a coarser fibre, both silks are the product of the same worm. For waste-spinning purposes the China tussah is preferred on account of its finer thread, but throwsters hold to the Indian as being cleaner and firmer. Although the *Mylitta* is really the only variety of the *Antherea* family which produces real tussah, there are a score which produce similar silk, all belonging to the same genus of insect. Whilst the *Bombyx mori* produces the finest silk, the fibres measuring from $\frac{1}{1600}$ to $\frac{1}{1000}$ in. diameter, the *Antherea mylitta* produces the coarsest silk, which varies in diameter from $\frac{1}{1000}$ to $\frac{1}{500}$ in. diameter.

The colour of the *Bombyx mori* silk varies from pure white to creams, and yellows to rich orange; but after boiling or discharging, the darkest shade will come out cream; whereas the tussah which varies from light cream to dark red-brown, will not give up its colour so easily, and it is only by the help of peroxides, or otherwise chemically treating it, that light shades can be obtained. Comparatively speaking, very little of the so-called tussah waste which comes to this market is really tussah; at least, it is not the product of the *Mylitta*, but of the many wild varieties which abound in China and India. A great producer of what is called the Indian tussah is the species known

FIG. 3.—*Antherea mylitta*, cocoon, moth.

as *Assam* of the *Antherea* family, known by the natives as *Muga*. The *Antherea royli*, which is bred in the Himalayas at a great elevation, produces one of the best Indian tussahs.

Doubtless the difference in texture between the Indian and China tussah, the product of the *Mylitta*, is due partly

FIG. 4.—*Yama mai*, larvæ, cocoon, moth.

to climatic influences and partly to the difference in food. The leaf of the oak is the best-known food for this class of worm, but there are a score of different varieties of leaves on which the worm thrives. Another genus belonging to the *Antherea* family, and one which is valued very much in Japan, is the *Yama mai.* Fig. 4 shows the worm A, the cocoon B, the male moth C, and the female moth D. It is an oak-feeding variety, and spins a quality of silk which is much appreciated on account of its strength, but the colour is not so good as that of the silk of the *Bombyx mori*, the cocoon having a greenish appearance. The *Yama mai* can be reared very well in England, and out of fifty eggs sent to an expert in the first year of introduction to this country, forty-nine were hatched; the worms reared, spun their cocoons, forty-nine perfect specimens of moths emerged, and their progeny still exist.

The *Pernyi* is another variety of the *Antherea* group which can easily be reared in this country. It produces a good silk, very similar to the *Mori.* It is an oak-feeding worm and is indigenous to North China, where of late years much attention has been paid to the rearing of this variety for commerce.

Of the *Citernia* family the *Attacus Cynthia* is shown in Fig. 5—the worm at A, the cocoon at B, the male moth at C, and the female moth at D. It also is a valuable silk producer, and thrives in North China and Japan, feeding on the *Arlanthus glandulosa*, which is very similar to our ash. It produces a long greyish cocoon. The *Ricini* is the *Cynthia* introduced into India, where it feeds on the castor-oil plant and produces the silk known as Bengals.

Wild worms.—As reference has occasionally been made to wild silkworms, it is well to here state that the description applies to those varieties which are hatched out in the open without any attempt being made to cultivate them or keep them under cover, except perhaps in a very primitive way. Many of the cocoons of the wild worms are probably collected and the pupa killed to prevent the moth developing, and such cocoons will be reeled; but naturally the silk is not so good as that of the worm which has been carefully tended and shielded from climatic changes of temperature. In many of these wild

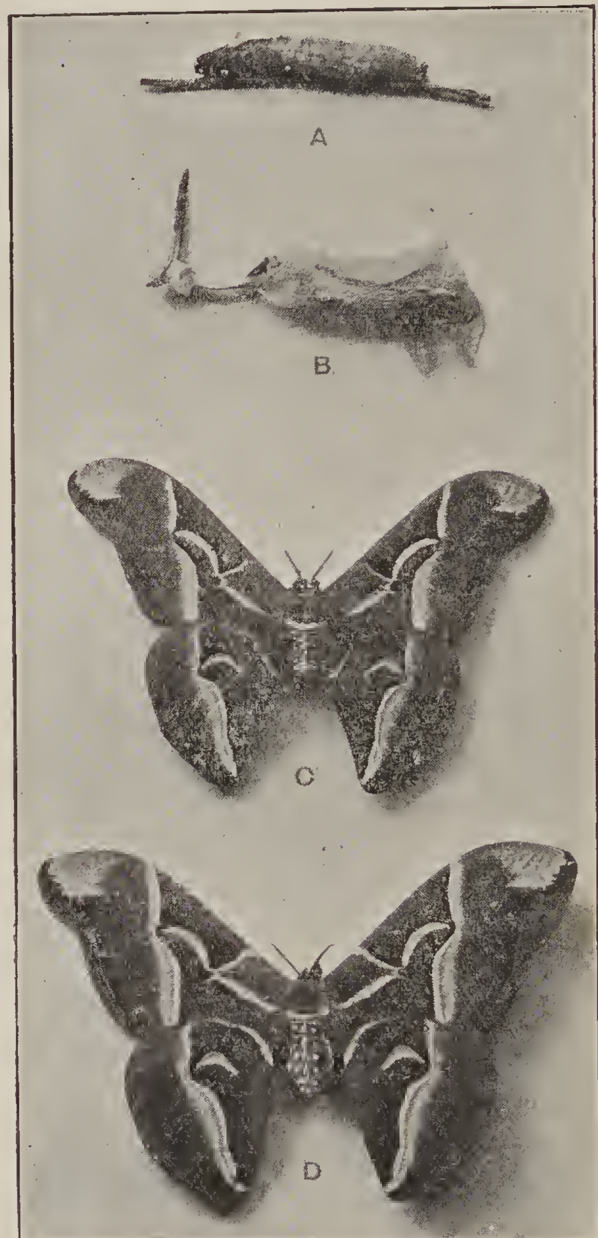


FIG. 5.—*Attacus Cynthia*, larvæ, cocoon, moth.

species the moths are allowed to burst from the cocoons, thus rendering them useless for reeling purposes. They are exported to Europe as "pierced cocoons," suitable only for waste-spinning purposes. Pierced cocoons are far more preferable to the silk waste spinner than perfect cocoons with the lifeless chrysalis inside, as in the latter case it is a troublesome process to separate the wormy matter from the silk, to say nothing of the extra weight of useless matter purchased. There are many wild varieties of silkworms in China and Japan.

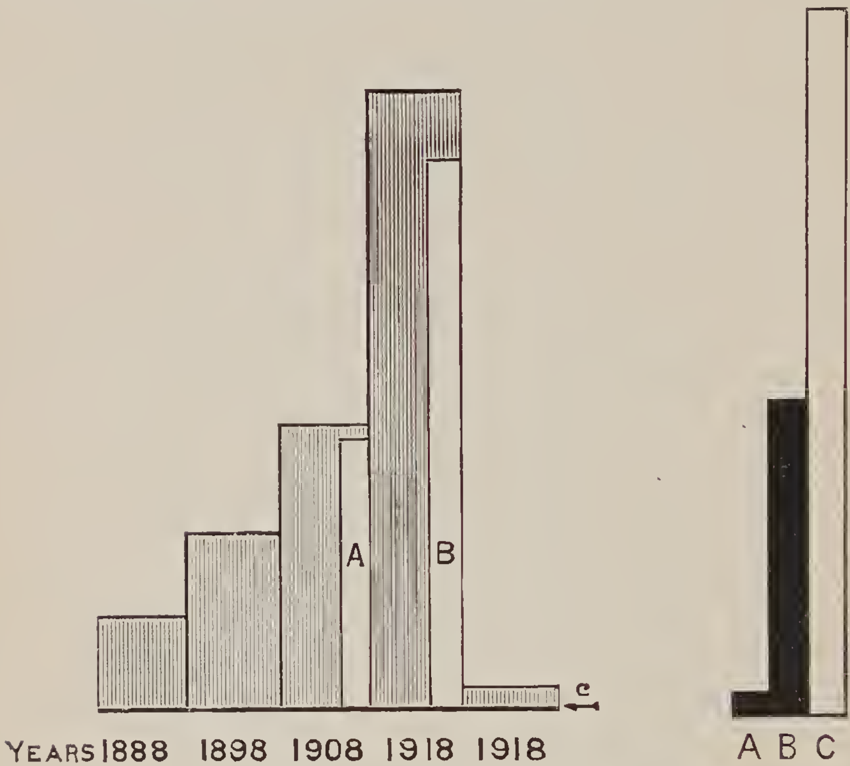
On the other hand, the *Bombyx mori* and other valuable producers of silk are most carefully and elaborately tended, either by the peasantry of the various countries in their own homes, or by large producers in establishments erected for the purpose, and employing numbers of attendants. The silk industry of the East is divided into two sections—namely, (1) the rearing of the worms and (2) the reeling of the cocoons. To give some idea of the amount of tending which must be necessary in rearing the domesticated worms it is calculated that the worms hatched from 1 oz. of "graine" eat during the thirty-one days which elapse from the day the eggs are hatched to the day when they commence spinning something like 1590 lb. of leaves. After the worms in the rearing establishments have completed spinning, the cocoons are carefully examined and sorted; the most perfect are set aside for breeding purposes, and the remainder are baked or steamed in order to destroy the life of the pupæ. The average production of 1 oz. of eggs is from 87 to 88 lb. of cocoons—that is, of course, unpierced cocoons—which includes the weight of the pupæ or chrysalis. The cocoons set aside for reeling are next sorted into grades—good, bad, and indifferent.

The raw silk trade of the world has expanded very considerably during the last twenty years, particularly in Japan. This country has recognised the value and importance of sericulture and has specially catered for the American market. The following diagrams illustrates the position of the silk trade at the end of year 1917.

In diagram Fig. 6 the columns A B, represent Japanese exports of raw silk :—

A = 15,230,000 lb. in year 1888.
B = 30,000,000 lb. in year 1918.
C represents proportion of English imports of raw silk 1,904,546 lb. in year 1918.

The other columns show proportionately the United States imports of raw silk, being 5,329,646 lb. in year 1888 and increasing to 34,846,197 lb. in year 1918.



FIGS. 6 and 7.—Raw silk.

The diagram, Fig. 7, represents the world's consumption of raw silk, excluding that of China and Japan which is unknown:—

A represents English consumption.
B ,, America's ,,
C ,, World's ,,

Column B indicates the commanding position attained by America in year 1911 when world's consumption amounted to 49,475,250 lb.

Since 1911 America has used still more silk.

CHAPTER II.

COCOON REELING AND QUALITIES OF SILK.

Cocoon reeling.—Reeling is a very simple but tedious process, and, on account of the silk fibre being so very fine, it takes a long time to reel 1 lb. of silk. One authority has stated that it takes from 2000 to 2500 silkworms to produce 1 lb. of silk. There is no very elaborate or expensive machinery required. Fig 8. represents a reeling machine,

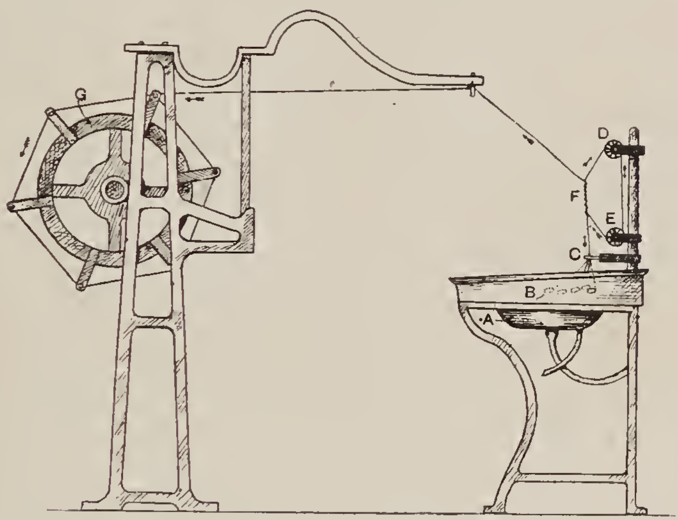


FIG. 8.—Cocoon reeling machine.

whose parts are as follows:—A, the basin into which the cocoons B are placed; C, a small circular plate through which the cocoon ends are passed to gather them into one end, which is conveyed over the small wheel D, then under the small wheel E, to the point F, where the thread is twisted round itself to weld the cocoon ends together before it passes on to the swift G.

The water in the basin is kept at a uniform temperature by means of steam. Into this water a number of cocoons are placed, and the operator whisks them about with a small stick or bunch of twigs until the natural gum with which the fibre is covered softens, and so allows the thread to adhere to the stick, when the outer coating of the cocoon, being coarse and uneven, is stripped off and put aside as waste, for the spinner of waste silk yarns. After this coating has been removed the reeler finds the end of the true or reelable thread, when four, five, or more of such ends are taken up and passed through the guide C to make one thread. The number of ends amalgamated varies according to the quality of the silk and the size or count required. Only the middle portion of a cocoon is reeled; the outer coating first spun by the worm is too coarse and uneven, the inner portion or last part spun by the worm is too fine, and hardly strong enough to bear even the weight of the cocoon. This unevenness in thread, varying from coarse to fine according as the silk is near the outside or near the inside of the cocoon, makes it necessary that great care be exercised by the reeler in running the different threads together to maintain the resulting thread of uniform size; and, as on this uniformity the value of the raw silk greatly depends, it will be seen that some skill and judgment is essential to a good reeler, it being necessary at times to vary the number of filaments.

Tsatlee reel.—In China silks there are three different reelings—namely, tsatlee reel, re-reeled tsatlees, and filature reels. The tsatlee reel is the commonest and oldest form in which the China silks come over from the East, but is fast falling out of favour, re-reels and filatures taking its place. The reeling machine is a very primitive affair, and, generally speaking, not much care is taken by the reelers to see that the number of filaments running together to make one thread is kept the same. Sometimes there may be ten or eleven running together to start with, but as the cocoons fall off or the ends break they are not replaced immediately. In fact, judging from the silk at times, it would appear that they are sometimes let run down until there are only about two running together. Then the correct number of cocoons or threads are pieced up and the reeling restarted; and so the process goes on, the thread naturally varying in thickness according to the number of filaments or cocoons kept up. In the tsatlee reel there is no attempt to make the hanks or skeins one even continuous thread, or uniform in length, and many times where the piecings of broken ends have been made there are faulty places which were better left undone. The tsatlee reels come over to Europe in the form of "books," twelve of which make up a bale of from 100 to 104 lb. These books are made up of twelve "mosses," which are again divisible into "slips." The length and size of these slips vary according to the quality of the silk. The books are bound together by bands of raw silk, which are generally very coarse and unsuitable for throwing. The ends of the books are covered by a kind of flossy silk, called "caps," to keep them clean. These silk caps are used for waste-spinning purposes.

The different qualities of tsatlees are divided into grades from No. $2\frac{1}{2}$ to $5\frac{3}{4}$, but there is no general classification under these grades, different shippers styling them according to their own recognised standard. The different qualities are known under a "chop" mark. Of the best-known qualities the following might be taken as standards for the grades:—

No. 1 .	No. 1. Black Lion.
,, 2 .	,, 2. Black Lion.
,, 3 .	,, 3. Black Lion. ,, 1. Buffalo.
,, $3\frac{1}{2}$.	,, $3\frac{1}{2}$. Black Lion.
,, 4 .	,, 4. Black Lion ,, 2. Buffalo. Red Elephant.
,, $4\frac{1}{2}$.	No. 3. Red Pagoda. ,, 3. Buffalo.
,, 5 .	Blue Elephant. Bird Fongling.
,, $5\frac{1}{2}$.	Yellow Elephant. No. 3. Mountain.
,, $5\frac{3}{4}$ (best)	Green Elephant. No. 4. Mountain. Gold Lion Kintze.
,, $5\frac{3}{4}$ (good)	No. 5. Mountain. Double Silver Elephant.
No. $5\frac{3}{4}$	No. 1. Almond Flower. Gold Kilin. Blue Phœnix Lanfung. M. Mandarin Duck. S.S.S. Dollar.
,, $5\frac{3}{4}$ (marketable)	Green Peacock Seeling. No. 2. Almond Flowers. Triple Pagodas. Choey Kilins. Bamboo No. 2. Mandarin Duck M.M. Kinfong Gold Pheasant. No. 2. Beautiful Woman.
,, $5\frac{3}{4}$ (inferior)	X. Running Deer. Red Stork. Red Kilin. III. Train Chop.

Re-reels.—As the name implies, these are the tsatlees re-reeled by the natives into smaller hanks, each of which is made up separately. In this process of re-reeling some of the foul threads and bad piecings are taken out, and the thread is subjected to a cleaning process. The hanks are sorted, and the fine sizes run together, as also the coarse sizes, and this is the reason re-reels are so much more uniform in size than ordinary tsatlees. Each skein being tied up separately and the hanks being so much straighter, makes them less expensive working for the throwster, and does not need the same amount of soap that tsatlees do to make them wind easily. Like tsatlees, re-reels are also divided into grades, and are shipped under a chop mark. These are—

EXTRA.

Buffalo Extra.
Pegasus Extra.
Black Horse Extra.

NO. 1.

Buffalo A.
Pegasus No. 1.
Black Horse No. 1.
Fan Chop Extra.
Gold Pheasant No. 1.

NO. 2 BEST.

Buffalo B.
Pegasus No. 2.
Black Horse No. 2.
Chrysanthemum No. 1.
Gold Flying Dragon No. 2.
Gold Pheasant No. 2.
Fan chop No. 1.

NO. 3 BEST.

Pegasus No. 3.
Black Horse No. 3.
Chrysanthemum No. 2.
Fan Chop. No. 2.
Gold Pheasant No. 3.

NO. 4 BEST.

Pegasus No. 4.
Black Horse No. 4.
Chrysanthemum No. 3.

MARKET NO. 1.

Flag Chop No. 1.
Cabbage No. 1.
Gold Peony Flower No. 1.

MARKET NO. 2.

Flag Chop No. 2.
Gold Peony Flower No. 2.
Cabbage No. 2.
Small Buffalo No. 1.

MARKET NO. 3.

Flag Chop. No. 3.
Gold Peony No. 3.
Cabbage No. 3.
Small Buffalo No. 2.

MARKET NO. 4.

Cabbage No. 4.
Small Buffalo No. 3.

Steam filatures.—These are the finest and most expensive silks produced. Only good silk is reeled thus, and filatures are more even and reliable for size than either re-reels or tsatlees. Formerly all silks used to be reeled in the cottages by the peasant and his family, and the water in which the cocoons were steeped preparatory to reeling was kept hot by a fire underneath the basin. By this means of obtaining heat it is impossible to keep the water at a uniform temperature, and the result consequently was uncertain, and bad reeling and tangled hanks were rather the rule than the exception. To overcome this difficulty, and with the general improvement of the industry and greater demand for silks from Europe, machines were adopted and the water heated by steam as per Fig. 8, and so kept at one temperature. These machines are gathered into factories called "steam filatures," and the cocoons, which have either been spun by worms bred on the premises or brought from up country by the peasantry, are reeled under skilled supervision. In these "steam filatures" great care is taken to keep the thread uniform in size or count and length of skein, the reeler being attentive to replace cocoons which have broken down, and so to keep the number of filaments comprising the thread always the same.

Chop Marks.—China filatures are also divided into grades according to chop, the best known being—

Extra.

Soylun Gold Anchor Extra.

Best No. 1.

Soylun Silver Anchor No. 1.
Keecheong No. 1.

No. 1.

Soylun Red Anchor No. 2.
Keecheong No. 2.
Gold Dragon No. 1.
Soyching Gold Eagle No. 1.

Best No. 2.

Sans Pareil No. 2.
Double Gold Dragon No. 2.
Tsuncheong Gold Double Anchor No. 1.
Excelsior No. 2.
Gold Globe No. 2.

No. 3 Best.

Double Anchor No. 2.
Excelsior No. 2.
Sans Pareil No. 3.
Gold Globe No. 3.
Double Dragon and Flag No. 2.

No. 3.

Double Anchor No. 3.
Double Dragon and Flag No. 3.

Another class of China raw silk, much in request for silk sewings and other purposes for which coarse threads can be used to advantage, are Hangchows and Kahings, which are reeled very similar to the tsatlee, being made up in books of 9/12 mosses. The diameter of the reel is, however, generally larger than the ordinary tsatlee, and in consequence needs larger swifts in winding. Of the Kahing's the best-known chops are—

WHITE KAHINGS.

EXTRA.

Tsuky Yuen Kinling.
Ching Yung Kinling.

NO. 1 BEST.

Tsuky Yuen Fongling.
Ching Yung Fongling.
Gold Lily Flower (Extra).

NO. 1.

Gold Lily Flower No. 1.
Tsuky Yuen Sueling.

NO. 2.

No. 2 Gold Lily Flower.

NO. 3.

No. 3 Gold Lily Flower.

NO. 4.

No. 4 Gold Lily Flower.

GREEN KAHINGS.

EXTRA.

Cicada No. 1.

NO 1 BEST.

Mandarin Duck Extra.

NO. 1.

M. Mandarin Duck.

NO. 2 BEST.

White Swan No. 2.
Green Stork Extra.
Gold Eagle Extra.

NO. 2.

M. M. Mandarin Duck.
Green Stork No. 1.

NO 3 BEST.

M. M. M. Mandarin Duck.

NO 4.

Green Stork No. 4.

Of the Hangchows the best-known qualities are shipped under the following chop marks :—

EXTRA.

Best No. 1 Lily Flower.
Best No. 1 Pagoda.

NO. 1.

No. 1 Lily Flower.
No. 1 Pagoda.
No. 1 Blue Lion.
No. 1 Blue Horse.

NO. 2.

No. 2 Lily Flower.
No. 2 Pagoda.
No. 2 Blue Lion.
No. 2 Blue Horse.

HANGCHOW TAYSAAMS.

Double Horse No. 1.
Double Horse No. 2.

The different chops, named previously under the heads of Tsatlees, Re-reels, Filatures, Kahings, and Hangchows, are all silks shipped from Shanghai, and are the silks universally known as "Chinas."

From Canton there are also different qualities of raw silk shipped, and in contradistinction to those shipped from Shanghai they are known as "Cantons." Chinas and Cantons are two distinct qualities of raw silk. The most striking difference, noticeable, even to the uninitiated, are —first, the colour; second, the texture or feel of the silk. Chinas, generally speaking, are a good white colour (although there are a few varieties yellow, but which are comparatively little known), even in the lower grades. Cantons, on the other hand, are a greenish brown, and vary very considerably. China silk is a firm, compact thread; Canton silk is not so firm, and works "fluffy" in throwing. These two defects are more noticeable when the silk has been discharged of its natural gum, for no amount of boiling—*i.e.* degumming—will give the Canton the same white bottom as the China. Like Chinas, Cantons are shipped in the tsatlee, re-reel, and filature reels, but as tsatlees they are best known as No. 1, No. 2, No. 3, and No. 4 Cantons, although they have different chop marks; but not so much importance is placed upon these chops as is the case with Chinas. The same remarks apply to the Canton filatures and Canton re-reels, which are likewise divided into grades—extra 1's, 2's, 3's, and 4's. The falling off in the production and export of tsatlee Cantons is more pronounced than with China tsatlees. The shipments go less every year, more silk being filature-reeled and re-reeled for America and the Continent.

Japan raw silk.—Practically all Japans are filatures or re-reels, and the bulk of the silk shipped to this country is shipped as filatures, America and the Continent taking a fair quantity of re-reels as well. The re-reels from Japan are very fair for cleanliness, and fairly even in thread. The different filatures have their respective chop marks, some of which are very well known, such as the "Kamiesha stags" and the "Riojiokan," but, generally speaking, they are bought and sold by grade. For all practical purposes, the following represents the different qualities shipped :— Extra : No. 1 ; Nos. 1, 1½ ; No. 1½ ; Nos. 1½, 2 ; and No. 2 ; but in buying "to arrive," the throwster or manufacturer generally stipulates the shipper, or shipper's mark, as one mark of Nos. 1, 1½ may only be equal to another shipper's No. 1½ or 1½, 2. In the case of buying on the spot from samples, the shipper's mark is not so important, as the silk will show for itself, except that certain shippers are well known to be careful in their selections and inspection. Japan silk is a good, clean silk, strong and fine fibre. The colour is greyish white, but not so white as Chinas. Japans are made up in books, but these contain separate hanks. The number of books in a bale varies. Each book weighs from 4 lb. 4 oz. to 4 lb. 12 oz., and a bale scales from 140 to 150 lb. The great shipping centre for Japan is Yokohama.

Bengal raw silk.—Coming west, there are the well-known Bengal silks, which are all filatures or re-reels. They are quite a distinct variety from the China, Canton, or Japan silks. The colour is a bright yellow, except some little which is a greenish white, and is not so appreciated as the yellow. Bengals are not made up in books like the other Far-Eastern raws, but are packed in bales with the different heads loose, each bale weighing about 140 to 150 lb. Of Bengals there are three crops in the year, and these crops are known as bunds, and the three bunds are named March bund, July bund, and November bund. Of these the last named is the best quality, and is usually the most sought after. The November bund silk arrives in this country about April or May, the March bund in September, the July in January. The silks are reeled from 10/14 to 45/50 deniers—*i.e.* from 23,100 yards to the ounce, to 6500 yards to the ounce, but the bulk are 16/20, 20/25 and 26/30 deniers—the latter, say 9180 yards per ounce, being a favourite size in this country. The best-known qualities are the Soleil (a special re-reel quality and much appreciated on the Continent), Surdahs, Rose Filatures, Cooldahs (also better known on the Continent), Gonateas, Bangettys, Rangamattys, Budderpores, and Chandpores. Calcutta is the great shipping centre for "Bengals."

European silks.—These are, with the best Japans, the finest and most expensive silks used commercially, and can be had as fine as 8/10 deniers, which is equal to 31,000 yards to the ounce. The district in which the worms are reared and the silk reeled gives the name to the silk, and some of the best-known qualities are the Cevennes, Piedmont, Frioul, Briance, and Messine. All these silks are filature-reeled, but the diameter of the swift used varies. The usual colour is yellow naturally, but there is some greyish white, which is well liked. A bale of French or Italian raw contains 100 kilos. = 220 lb. about. These raws are divided into grades: Extra classical, classical, sublime, and common.

Comparatively speaking, very little European raw silk comes to this country except for using in the singles. Very few throwsters buy it, as they cannot throw it to compete in price with the warp and weft made on the Continent, and which can come to us free of duty. The cost of labour is so much cheaper there than in England, and their machinery is so much better adapted for throwing these fine silks than ours, that the continental throwsters can deliver thrown silk in England from 6d. to 9d. per pound cheaper than an English throwster, granted that the latter can buy the raw silk as cheap as the former. Some of the large filatures also have their own throwing mills, so this again tends to diminish the cost of production. On the other hand, America is a large buyer of French and Italian raw silks, but not of their throwns. Fortunately for the American throwster, the raw silk goes into the country duty free, but on warp and weft there is a very heavy duty to pay—over 30 per cent. *ad valorem.*

Doppione.—Another class of raw silk of which mention may be made is the Doppione, which is generally of a light yellowish colour. This raw silk is coarse and uneven, and is reeled from double cocoons—*i.e.* in the case where the worms have spun their cocoons side by side and so joined them that it is necessary to reel them together, the end of neither cocoon being free without the other. The production is comparatively small, and its unevenness makes it unsuitable for good class work; hence its use is confined to the manufacturing of the cheapest materials and heavy sewing threads.

Silk crops.—Mention has been made under the heading of "Bengal Silks" of three crops per annum. More than one crop in a season is usual in several districts in the various silk-producing countries, for the reason that in the early spring, with some species, the ova is hatched out, worms fully developed, cocoons spun, moths emerged, and they in their turn have deposited ova which is hatched out quickly; and the whole development from ova to moth and reproduction occupies such a short time that from two to five crops of cocoons are reared in one season.

Shipping raw silks.—To combat against the well-known cunning practised in the Chinaman's reeling and packing, the European and American shippers at Shanghai and Canton are compelled to have a fully qualified inspector, with assistants, to examine very carefully every book of raw silk before packing into bales and shipping. As far as is possible, without damaging the silk, the books are opened to see if there has been any inferior silk surreptitiously packed inside, which is often the case. Sometimes the outside mosses are really first-class silk, and look exceedingly well, being good colour, bright, and fine in size; but the inside layers have been most cleverly made up of coarser, darker, and inferior silk. There have been cases on record where other material beside silk has been found inside the books to give weight to them, but it is only fair to say that there are some reliable Chinese dealers whose silk can generally be taken to be what it is represented to be, though of late years in China all chops seem to have more or less deteriorated, and on this account the old recognised differences between standard chops such as gold kilins, yellow and blue elephants, can no longer be taken as a working basis of relative values and prices.

After the receipt and passing of the silk, it is packed first in a fine cotton cloth commonly termed a "shirt," which is roped round with a kind of grass rope of native manufacture. The silk in the shirt is afterwards packed in a series of layers of coarse matting and paper, the outside wrapper marked with the shipper's mark and consecutive numbers. On arrival of the silk in London,[1] where it is generally warehoused by the London and India Docks Joint Committee, the bales are carefully examined to see if they have been damaged by sea-water or other cause. This can generally be detected at once without opening the bales, as the outside wrappers will show any trace of dampness. If any of the bales are damaged, the merchant generally gives instructions at once to have the run (*i.e.* the whole of the bales which make up the parcel) "worked" (*i.e.* examined). This is undertaken by the Dock Company, who open out the bales and examine each book separately to see if there is any trace of damage. Any doubtful book is placed on one side and replaced by a sound one taken from one of the other bales. This process goes on through every bale, and in a run of, say, 20 bales of Chinas, there are frequently as many as 20 damaged books, which are put in the last two or three bales. These last-named bales are then assessed for damaged books by a silk broker, who gives a certificate to say that he has examined them, and considers so many are damaged, for which the insurance company are liable. These bales are now "starred" by the Dock Company, and entered as such in their books. The bale marked thus "*" is always under-

[1] Silks can now be weighed and conditioned at Bradford Conditioning House.

stood to be a damaged bale, and on any bale so marked the buyer is entitled to claim the allowance as originally claimed from the insurance company. The damaged silk is not charged for at all; thus, if in the ordinary way a bale was chargeable 104 lb. net, and on inquiry it was found that 4 lb. had been allowed for damage, the bale is only chargeable at 100 lb. net. Generally speaking, all bales are worked by the Dock Company on arrival, but this, of course, is at the discretion of the owner.

After the silk has been worked the books are made up in hessians, of which the uniform weight is 2 lb. for China or Canton tsatlee, and 3 lb. for Bengal or Japan raw silk. On the outside of this hessian is marked the shipper's mark, the number of the bale, the stock number, the name of the ship in which it arrived, and the date of arrival. The bales are then ready for stocking in the Docks Committee's warehouses or for delivery to the owner. The Dock Company not only undertake the working of the bales, but also the weighing, taring, and sampling, which, being done by an independent party, are accepted by the trade as final in case of a dispute respecting weight.

On bales of tsatlees weighing from 100 to 108 lb. there is an allowance made of 2 lb. per bale, which is termed scorage. For instance, if a bale scales 106 lb. in the hessian with a tare of 2 lb., the invoiceable weight is 102 lb., although the net weight of silk is 104 lb. This 2 lb. is allowed for bands and unwindable silk. Odd ounces are not charged for. A bale weighing 104 lb. 12 oz. is only charged at the same weight as one scaling 104 lb. In the case of Japans and re-reels, in which there is no unworkable silk in the shape of bands, the actual tare of the paper and strings round the bundles is taken. The Dock Company strip three or four books, and having obtained the weight of the paper and string, take a percentage as compared with the weight of silk stripped, and this allowance is made on the whole parcel. This varies from 1 to 2 per cent. on the net weight.

Terms.—Raw silks are bought and sold on what are called "Company's terms," an abbreviation of "The East India Company's terms." Briefly, these terms are understood to be three months' prompt from date of purchase in the case of silk on the "spot," and three months' prompt from date of arrival in the case of silk bought "to arrive." During these three months the buyer is at liberty to allow the bales to lie in the warehouses or to take delivery of all or part of his purchase, but only on payment of the proper proportion of value of the silk cleared —*i.e.* delivered. "Company's terms" are also known as "London terms," in contradistinction to "Lyons terms." The latter means silk delivered free in Lyons and conditioned in the Lyons conditioning-house. The weight invoiced to the purchaser is the conditioned weight, no allowance being made for scorage, and cash is due on delivery with a 90 days' rebate at the rate of 6 per cent. per annum.

CHAPTER III.

SILK THROWING.

SILK throwing is the name given to a series of operations through which the raw silk is worked to convert it into a weavable state for warp or weft, and the produce from a silk throwster's mill is known as thrown silk. The various

FIG. 9.—Heads of silk; book of silk.

kinds of thrown silks best known are: Singles, used for warp or weft; Tram, used for weft; Organzine, used for warp; No-throw, used in the Derby and Leicester trade; and Silk Sewings, used by tailors and in the boot trade. Fig. 9 shows a book of silk at A, and gives a good idea as to how a tsatlee-reeled China or Canton is made up. This book can be split up into mosses and lesser slips. B shows a head or skein of Bengal silk opened out, while C and D are each a head of Japan and Italian filature respectively.

Splitting.—Taking first the tsatlees, the throwsters divide the books into the separate mosses (twelve mosses to a book). They are generally found entirely apart from each other, so there is not much difficulty in parting them unless the silk has been damaged in some way. The mosses, however, are too large and unwieldy to be put upon the swifts of the winding machine, for the strain on the single thread in the process of winding would be so great that the thread would be constantly breaking and so causing waste; hence it is necessary that the mosses be split up into smaller skeins, which are generally termed slips. The sizes of these slips vary, but it is the splitter's object to get them as nearly all one size as possible. One moss is generally split into about three slips. In some classes of silk where the reeling from the cocoon has been carelessly done this is a very tedious process, on account of the tangled threads, and unless the attendant is a very careful worker she can easily spoil a fair amount of silk. The machine used is but a simple contrivance, as will be seen from Fig. 10. The moss or skein S is opened out by the operator—generally a girl sitting on the seat C—and placed over the two barrels or swifts A, the bottom one being movable in a slot B so as to accommodate mosses or skeins of different diameters. The operator then places her hands in between the two sides of the skein, and revolves it quickly round and round the swifts in the direction of the arrows D, D, which operation causes the skein to open out on the face of the swifts, tending to get the threads straight, and as nearly as possible in the same position as when the moss or skein was on the cocoon-reeling machine. In this way the moss is made ready for being divided into the required number of slips of similar size at the most suitable places, and split or parted with a minimum of broken threads between each division. The moss ready for division into three slips or skeins is shown at the top of Fig. 10. In this parting of the books into mosses, and the splitting of the mosses into slips, there is a certain amount of waste made, known in the trade as parters' and splitters' waste, which is always "bright"—that is to say, free from soap or other similar matters.

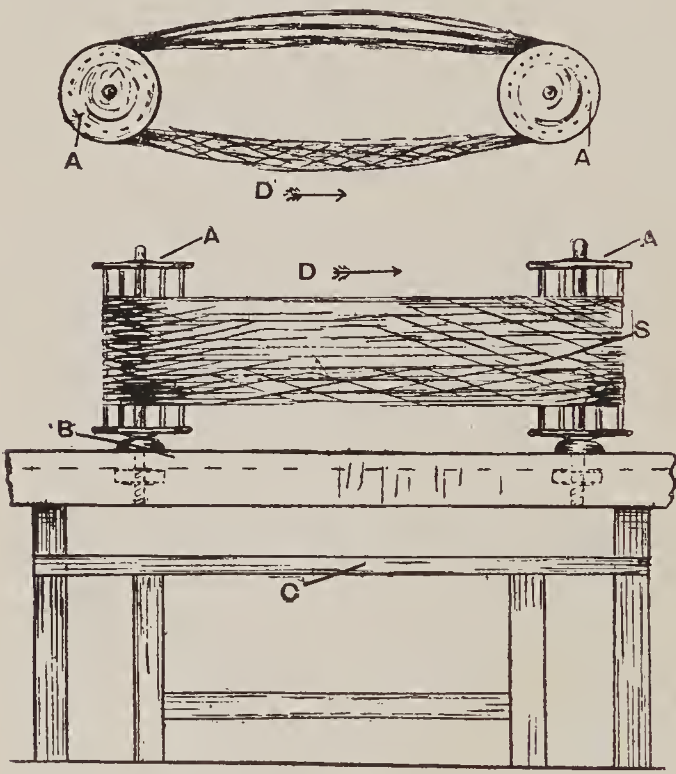


FIG. 10.—Splitting mosses.

Sorting.—Having thus divided the books into workable slips, these are now carefully gone through and sorted—the coarse from the fine, the good colour from the bad and indifferent, the nibby and doubtful removed, each being put in a separate heap and kept entirely apart until the doubling process, when some throwsters double or fold a *fine* and a *coarse thread* together to get a *desired* size or thickness—which, however, is very unsatisfactory, and is a practice not resorted to now by the best throwsters. Generally speaking, it may be taken that when once the slips have been sorted they go through the mill entirely separate. It is part of the duty of the sorter not only to divide the slips into the different grades, but also to detach loose ends and straighten them. This process therefore entails waste again, and is known as sorters' waste, which is also "bright." Of the waste produced by throwsters the most valuable are the three previously mentioned—namely, "parter's," "splitter's," and "sorter's."

To none of the previous processes are the filatures or re-reels subjected, because they are already in the slip-state, and are made of such a convenient size for winding that it is not at all necessary to divide them further.

Bright silk.—At this stage the throwster must decide whether he will throw the silk "bright," or, as is generally the case in England with tsatlee reels, whether he will work it with soap. The term "worked bright" is understood in the trade to denote that the slips have not, prior to winding, cleaning, and throwing, been washed or soaked with soap, which is done to make the silk wind more easily. Filatures and re-reels, and on the Continent tsatlees even, are generally "worked bright," but the continental throwsters use ingredients other than soap of an oily nature, by using which they help the silk to wind better, and do not detract so much from the lustre of the silk as soap does. Many of the compositions used abroad, whilst softening the silk for winding purposes, add weight to it, a certain proportion of which is retained in the fibre and will withstand boiling liquors to a remarkable degree. Slips to be thrown "bright" are at once taken to the winding frame.

Washing.—Washing is not an elaborate process. The slips or hanks are taken and soaked in a solution of hot water and soap. The hot water, combined with the alkali of the soap, softens the natural gum or bast of the silk and tends to make the thread pliable, and to loosen the threads one from the other; and the fatty matters of the soap counteract the tendency the fibres would have, on drying, of matting together. It is essential that a good white oil soap be used on account of the absorbent power of silk, as an inferior soap of bad colour will dry yellow on the silk and thus diminish its value by affecting its colour, and may possibly make it sticky in working. The question of soap used in the washing process is also a very important matter to the silk waste spinner who buys the throwster's waste. Where dark-coloured soap is used, the waste from the processes following the washing is of a bad colour, which no subsequent boiling will dissipate. Some waste, which immediately after the winding and cleaning appears a good white colour, turns a yellowish brown when stored in a room which exposes the waste to sunlight. This is not the fault of the silk, but of the soap used in washing.

The compounds used in place of soap are often sprinkled on the silk by means of a brush, and the silk allowed to lie twelve hours or so until the bast is well softened. As mention has been made of the silk absorbing a proportion of the soap, a question naturally arises as to what extent this weighting is carried on. Some throwsters use more soap than others, but a good average, and an average which some throwsters guarantee, is that for every 1 lb. of thrown silk the net result of boiled-off silk—that is, silk free from soap and its natural gum—should be 11½ oz. net—a loss in degumming of 28 per cent. Silk thrown "bright," when boiled off, loses only from 20 to 22 per cent., which shows that soaped silk has picked up from 5 to 8 per cent. of soap; but some manufacturers complain of continental "throwns" being adulterated with some compound which spoils the "bottom"—*i.e.* colour—of the silk, and makes it impossible to thoroughly boil off the thread a small percentage of the ingredients used.

Drying.—After the washing comes the drying, which is generally done in one of the two following ways: The slips are freed from as much moisture as possible by wringing by hand, and are then put into a hydro extractor, which dries them so well that it is only necessary to hang them up for a few days in a room of ordinary temperature. Other throwsters have a steam heated stove, in which they hang their washed slips for drying.

Winding.—The winding and following processes are the same for soaped slips as for silk thrown "bright." Winding, as the word implies, is the name given to the process by which the slips, washed or "bright," as the case may be, are run in a continuous thread on to bobbins. The winding machine consists of a series of swifts A, Fig. 11, placed side by side and revolving on their own axes quite independent of each other. The slip or hank is placed upon these swifts, one hank on each swift, as shown at B, and when in position the attendant's first duty is to find the end of the silk on the outer side of the skein. This end she passes through a guide or eyelet C, on to a bobbin D. The bobbin is revolved by means of a drum or pulley E, which is fixed firmly to a skewer or peg passed through the bobbin, and rests lightly in the brackets F. The small pulleys E are revolved by means of driving pulleys G, and the thread is traversed from end to end of the bobbin by means of the guide or eyelet shown at C.

By this means the thread is wound on the bobbin without any friction, which would tend to flatten it. When once the end of the silk is found in a hank it does not follow that the silk will wind in one continuous thread until the whole skein is complete, for in one hank there are frequently scores of lengths which the attendant is continually piecing up, necessitating her continual attention in finding fresh ends. There are also places in the raw silk which will not bear the strain of the tension between the bobbin and the swift, and so the end breaks. In such a case the attendant removes this fine place and continues to unwind by hand until she comes to the firm thread again. This fine silk which is taken out is put on one side and is known as "winders'" waste, and is what is called in the trade the fine, in contradistinction to the coarse or cleaners' waste made in the next process.

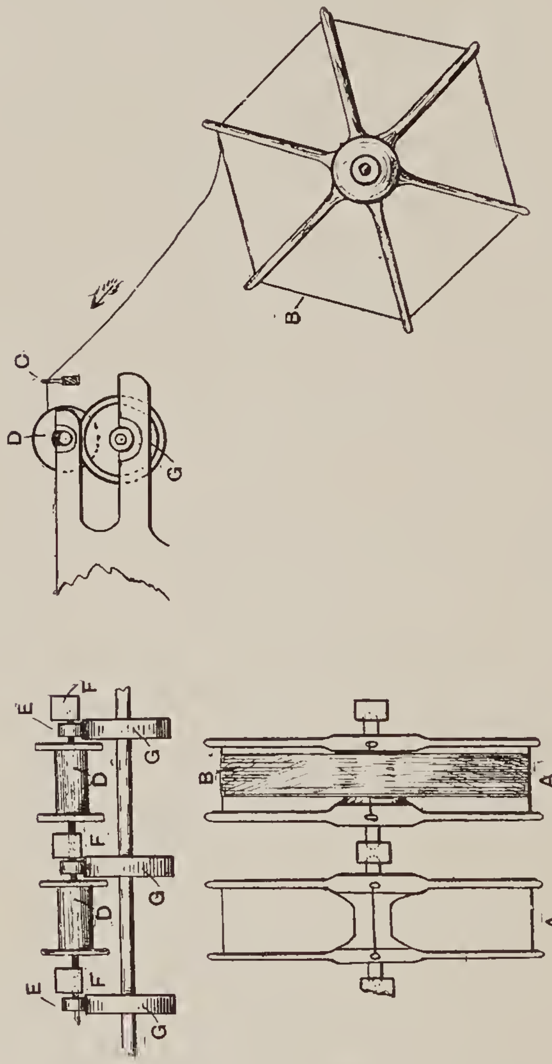


Fig. 11.—Silk winding.

Cleaning.—Sometimes during the winding, but preferferably after as a separate process, a clearing or "cleaning" of the thread from gouty, slubby, and foul places is attempted. The method adopted is as follows:—The bobbin of silk is taken from the winding frame, the thread re-wound on to a fresh bobbin, and the thread passed in its transit through a series of guides or cleaners, which may either be a steel plate with a slot in, or two parallel plates placed so close to each other that the presence of any bulky knot, husk, foul place, or coarse thread is immediately detected, and by means of a simple automatic contrivance the receiving bobbin, which is worked on the same principle as in the winding frame, is stopped. The attendant then takes out the faulty thread, pieces up, and the process continues. These rejections from the cleaning mill are known as "cleaners'" waste. Fig. 12 shows the cleaning bars, the one at A being open, and the other one closed. The opening is regulated to any requisite distance by means of the set of screws B, B. After the cleaning process, which is repeated two or more times to obtain the quality and the cleanliness of thread required, the subsequent operations vary according to what it is desired the silk should be converted into — whether no-throw, singles, tram, or organzine.

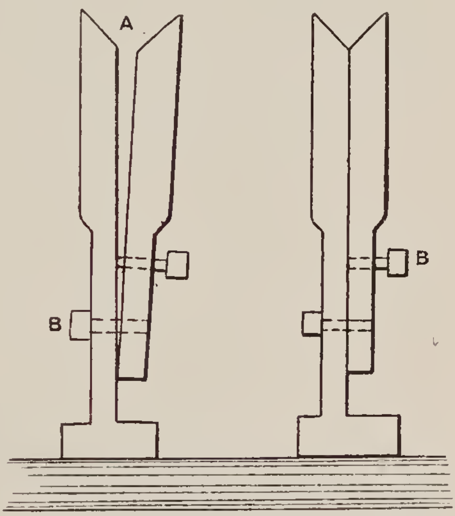


FIG. 12.—Clearer or cleaning bars.

No-throw.—No-throw, as its name implies, has no twist or spin (turns per inch) put into it beyond just sufficient to bind the respective filaments composing the thread together. It is silk taken straight off the cleaning bobbins—two, three or more ends doubled together; and if it could be used in that state would only require reeling into skeins, but, being a most unsatisfactory article to use thus, most throwsters put in a little twist. Even then great care is necessary in the reeling, or the threads separate and form "loopy" places, which are very objectionable, causing a weak thread, and it is to mitigate such faults that the thread is slightly twisted. Whilst so guarding against "loopy faults" it is essential that care be taken not to have too many turns per inch, or then it would be practically useless for any purpose, being too hard to cover well. The Derby and Nottingham markets take a fair quantity of this class of silk for fancy braids and the covering of cords for tasselling purposes.

Tram.—In the making of tram used as weft or shoot, two, three, or more bobbins of cleaned silk are used, the number varying according to the special requirements of the customer, which may be for what is termed two- or three- (or more) threads tram.

Two-threads tram and three-threads tram are current productions, but for special purposes, where a coarse count is needed, sometimes a four-thread tram is made. No twist whatever is put into the single thread used for tram. For example, if a three-thread tram is needed, three ends of cleaned silk are wound together on to one bobbin without any twist being put in. The machine used for the purpose is similar to the winding machine described in Fig. 11; but so as to ensure that a two-thread or a three-thread tram has two or three threads throughout its entire length, an automatic stop motion is used, which throws the receiving bobbin out of gear whenever a thread breaks between the receiving bobbin and the bobbin from which the thread is being unwound. Fig. 13 shows a side section of the machine and the winding or doubling process. Two, three, or more bobbins, as required, are placed on the bobbin board A, in a line with the receiving bobbin. The thread T is passed from the bobbin B through the flyer F over the guide rod G to the detector D, and thence through traverse guide on to the receiving bobbin H. When the thread breaks, the detector drops on to the lever L, which is balanced in such a way that the weight of the detector causes the lever to tilt up and project its end J into contact with the star wheel S, fixed on the spindle which goes through the receiving bobbin, thus stopping the revolution of the bobbin until the broken end is tied up. The receiving bobbin is revolved in exactly the same manner as shown in Fig. 11. The position of the flyer F is so arranged that the thread does not run any chance of catching against the bobbin head. The bobbin containing the desired ends is then taken to the reel, Fig. 16, or to the spinning mill

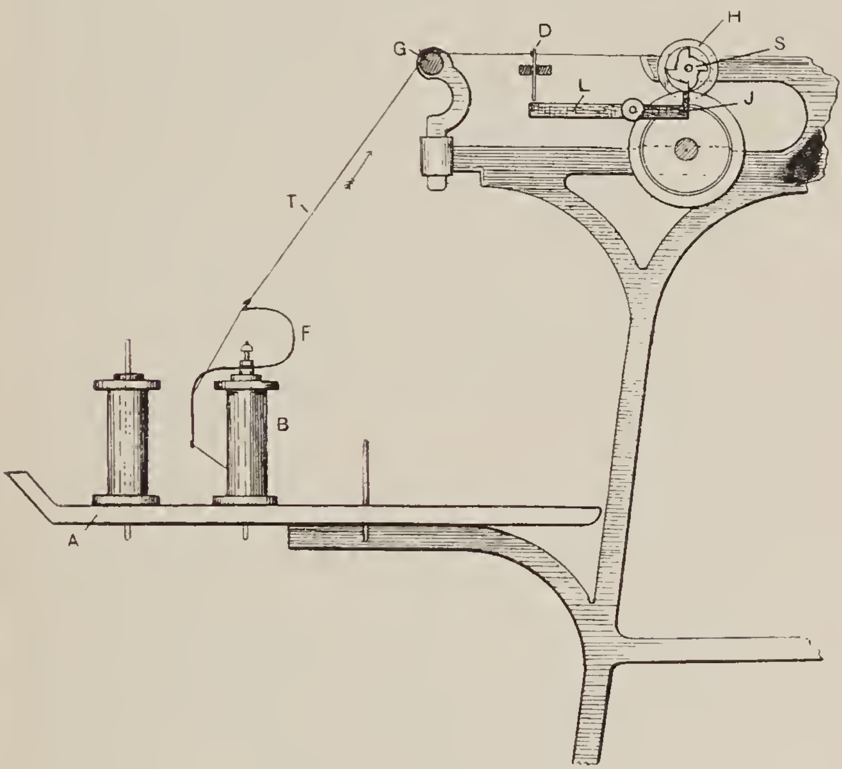


FIG. 13.—Silk doubling.

described under the heading "Organzine," and a very slight twist put in there. This twist, spin, or throw, as it is differently termed—really turns per inch given to the thread—is varied to suit the purpose for which the silk is required, ordinary twists, suitable for Macclesfield, Bradford, and Glasgow trade, being about 2½ turns per inch, whilst for the elastic web trade and some classes of hosiery a much harder twist is needed—say about 5 to 6 turns per inch.

Organzine.—Like tram, this is made up of two or more threads folded together; but, having to be used for warp in manufacturing purposes, it is necessary for it to have enough twist in the single thread and in its folded state to ensure its being able to withstand the strain and friction of the harness, healds, and reeds in the loom. Thus in two essential details does it differ from tram; for whilst the latter contains no twist in its single threads, organzine singles are spun or twisted on the throwing or spinning mill, and are again spun, or twist put in, after being doubled or wound together to make a two-fold or three-fold yarn. Again, a great deal more twist is necessary for organzine than for tram, for the latter is kept as soft as possible, so as to make as bulky a thread as can be, for the sake of lustre and fulness in the finished article, whilst the former is fairly hard-twisted to give it strength. A very good twist for organzine of good quality is 19 to 21 turns per inch, but different throwsters hold very varied opinions as to what is best.

Spinning.—The spinning or throwing mill is illustrated in Fig 14. The bobbin A containing the singles is placed on the spindle B. A circular weight is placed on the top of the bobbin to keep it steady, and above the weight is fixed a light wire flyer C, through which the thread is passed, and from thence on to the receiving bobbin D. This bobbin is often made of lead, and is driven by means of a roller or wheel E, and whilst the thread is passing from the bobbin A in the direction of the arrow to the receiving bobbin D, the spindle is being revolved by means of a band or friction strap passed over the tin cylinder G and spindle wharf H, by which means any requisite amount of turns per inch can be put into the thread. For economy of space and labour, the spinning frame is built in tiers, two or three rows of spindles one above the other, as shown by the drawing. Fig 15 shows the usual flyer used in spinning and winding, which is fixed so that the leg receives the thread midway between the heads of the bobbin to ensure as little friction as possible on the thread. For various counts of thread different flyers are used. When the folded threads of organzine are twisted together, the twist is put in the reverse way to the twist on the singles, and about 9 turns per inch is an excellent twist

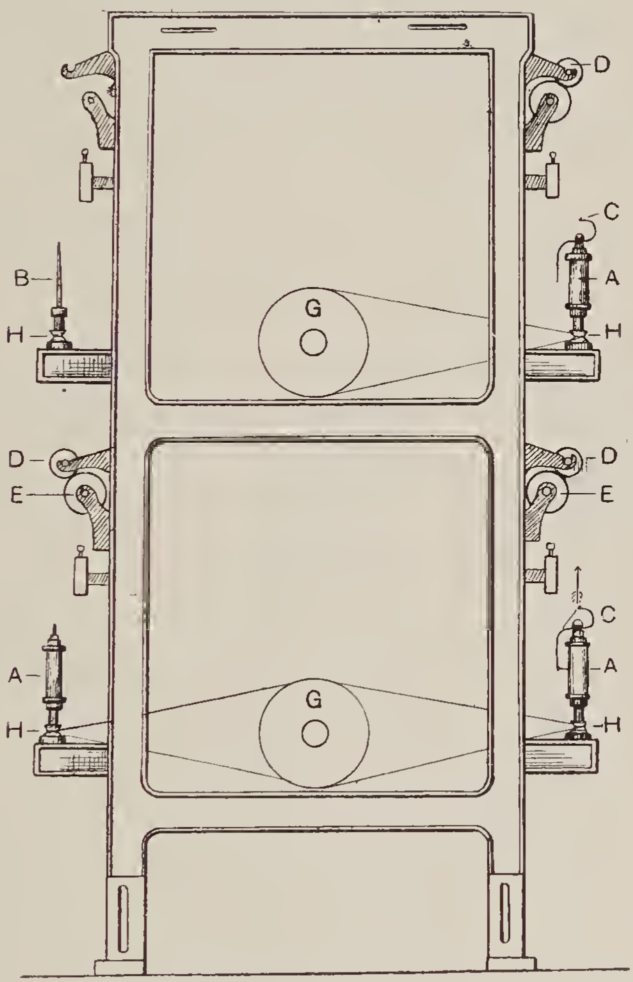


Fig. 14.—Throwing mill or spinning.

on the doubled thread. In Fig. 15 the parts marked A are made of metal and the parts marked B of wood.

Singles.—These consist of the single filament of raw silk, either untwisted as delivered by the cocoon reeler, or sufficiently twisted to enable it to withstand the operations of boiling or dyeing through which it may have to pass before weaving. It is used for warp or for weft for different makes of cloths, and is hard or soft spun in accordance with the requirements of manufacturers, whether for use as warp or weft.

Reeling.—The bobbins of doubled silk are taken to a reeling frame, Fig. 16, and placed on the spindles A, which are fitted up and revolved in the same manner as the spinning frame spindles. The thread is passed through the flyer eye and on to the swift B, which draws

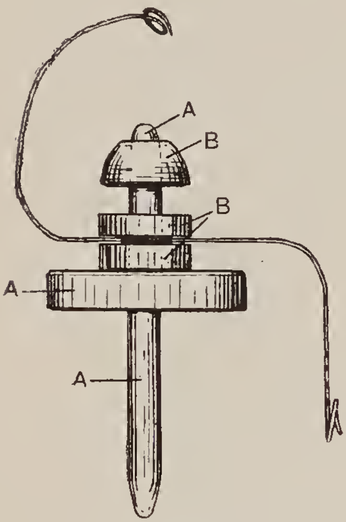


Fig. 15.—Flyer.

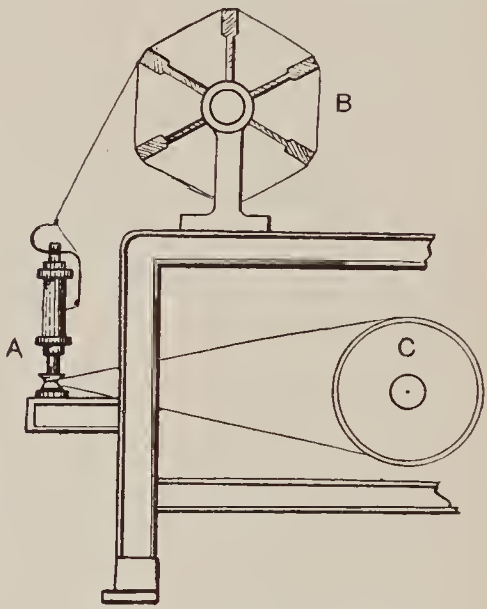


Fig. 16.—Reeling Frame.

the thread off the bobbin. The spin or twist necessary is put in during the progress of the thread from bobbin to swift by the revolution of the spindle which is driven by the cylinder C. There are two different terms for reeled skeins—namely, "ordinary" reeled and "grant" reeled. An ordinary reeled skein will measure in length from 1000 to 2000 yds., but a grant reeled skein may go up to 10,000 yds. in length. The difference between the two reels is in the traverse of the thread during the reeling operation. An ordinary reel will traverse the thread from side to side about 1½ in., but the grant reel much more; and the traverse of the latter is also very quick, with the result that there is less liability of the thread becoming entangled and matted during boiling off and dyeing. Then, again, in winding from hank to bobbin for warping purposes, a grant reeled skein runs better, and that, combined with its great length, is an economy in winding.

Ordinary cross reel skeins in England are reeled 1000, 1500, or 2000 yds. long, but on the Continent they vary very considerably, although 500 and 1000 metres are the standard lengths of a skein of ordinary reel. When the skeins are all the same length and the sizes properly divided into bundles or hanks, continental throwns are termed *tours comptés*—generally written "t.c."; and when the lengths of the skeins vary, and are consequently not carefully subdivided, they are offered as *non tours comptés*—written "n.t.c." English throwsters do not mix up skeins of different lengths in the same parcel of thrown silk like their continental competitors. Until late years throwsters here used to always reel their thrown silk ordinary reel in the first instance, and weigh each skein for size and count, and then, after sorting into the separate sizes, if the manufacturer wanted grant reel, they would rewind the skeins on to bobbins, piecing each short skein up for requisite lengths, and then re-reeling from the bobbins. By this means the resulting skein was more accurate in size throughout its entire length than is the case when grant reel skeins are reeled straight from the throwing mill bobbins into 5000, 7500, or 10,000 yds., and then sized or deniered.

Sizing.—This is an important part of the throwster's duties—namely, the dividing of the silk into sizes, *i.e.* count. All silks vary in thickness in a given length, and when it it is understood that the best chops of Chinas yield in two-threads tram or organzine sizes from 30 to 60 deniers, —that is to say, some sizes quite double the thickness of others—the importance of sizing will readily be recognised. Naturally the finer sizes will do better for finer and more delicate work than the coarser silk. The general way adopted is to "dram" or "denier" the skeins by means of a spring balance, Fig. 17. This consists of a small instrument with a fairly delicate spiral spring, and an index finger attached, the former enclosed in a wooden or metal covering to protect it from moisture of the atmosphere and from dust. On the outer covering are the figures denoting the different sizes from 1 to 200 or more deniers, or, in drams, 17 deniers to the dram. At the end of the spring is attached a hook on which the skein of silk for sizing is hung. The deniers or drams denoted on the indicator are marked so that the index finger attached to the spring will be brought down to such a size or weight, when a skein of exactly the same weight is put upon the hook. Supposing the hank to be sized measures 1000

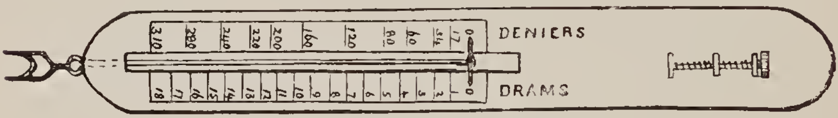


Fig. 17.—Denier scale

yds., and when put on the hook the index finger points to $3\frac{1}{4}$ drams, then the actual size is known as $3\frac{1}{4}$ drams to the 1000 yds., or 55 deniers, which is equal to 5040 yds. per ounce. Had the skein been 1500 yds., and indicated $4\frac{1}{2}$ drams on the dramming machine, the actual size would be 3 drams to 1000 yds., or 51 deniers, equal to 5600 yds. per ounce, about.

On the Continent the sizing of the silk is done at the conditioning-houses: in the case of grant reel filature thrown silks always, and sometimes with regard to ordinary China thrown silks. In the conditioning-house, wrappings of, say, 100 metres are taken from different skeins of silk, and their weight taken most carefully on well-regulated machines. The sizes of each wrapping are taken (say about twenty from each bale conditioned), an average struck, and the silk offered and sold as such and such sizes, representing the result of the conditioning-house test. Supposing, for instance, the conditioning-house returns showed that out of twenty wrappings tested the result was :—

3 skeins 20 deniers	The average would be 24·90 deniers, and the silk would be offered as 24/26 deniers.
4 ,, 22 ,,	
3 ,, 24 ,,	
4 ,, 26 ,,	
3 ,, 28 ,,	
3 ,, 30 ,,	

Generally, the differences are not so great as the above, as the silk is sized to half-denier, but the example given shows the method.

Make-up.—Trams, organzines, and no-throw are made up into hanks, each hank containing a number of skeins, varying, as they are 1000, 1500, or 2000 yds. ordinary reel, or 5000, 7500, or 10,000 yds. grant reel. These hanks are made up into bundles, the bundles of organzine generally being short and weighing from 6 to 8 lb. Tram bundles are long, the length of the reel, in fact, weighing from 12 to 17 lb. Different throwsters have their own way of making up. The bundles are tied up in the ordinary way with string, but as there is always an allowance made to the buyer on account of this, throwsters are not very sparing in this respect.

Weights.—On English thrown silks there is what is termed "scorage" allowed, which is 1 per cent. deducted from the actual net weight of the silk in the bundles. Supposing there to be eight bundles of China organzine, weighing 50 lb. 8 oz. net as they stand with the strings on, the weight chargeable is 50 lb. only, the 8 oz. being allowed to cover string and tie bands. In the case of continental thrown silks, which are not generally made up in bundle form, but in bunches, the silk is charged conditioned weight. A bale of thrown or "net" silk for conditioning is sent to the conditioning-house, where the tare is entirely stripped off and most carefully weighed. First the actual gross weight of the bale is taken, and after taring the net weight of the silk is obtained, and on this weight the subsequent calculations are made. The process of conditioning is a very important work, and the most delicate scales and manipulations are necessary, as only a few heads from each bale are actually tested, and from the result of the weighings of these few heads the throwster has to abide in charging up his bale.

The heads tested, which have previously been most carefully weighed, are dried in a stove until absolutely free from moisture, and then weighed again, and the percentage of loss in weight is taken as compared with the original weight of the silk before drying. This percentage of loss is calculated on the weight of the whole bale, and so the absolute dry weight of the lot is obtained. This, however, does not mean that the silk is to be charged absolute dry weight, as it is a well-known fact that it contains 11 per cent. of natural moisture, which is therefore added to the absolute dry weight, and the result represents the weight chargeable to the buyer, who purchases on the conditioning-house certificate.

To overcome the risk of a seller taking out silk and putting moisture in the bale to make up weight after the issuing of the certificate by the conditioning-house, the latter remake up the bale themselves and seal it with the official seal, and this enables the buyer to see at once if it has been tampered with. The advantage to the buyer of conditioned silk is that he is certain to get the full weight of silk without paying for moisture over and above the legal amount, and there is absolutely no temptation to the throwster to turn out his silk in too damp condition, as he might be a very heavy loser by so doing should the conditioning-house authorities happen to test some heads which were considerably more damp than the actual bale as a whole.

The most prized qualities of silk are—

1. Its extreme brilliance and lustre, it being the most lustrous of textile fibres.

2. Its great strength, which is supposed to be nearly one-third of best iron wire.

3. Its elasticity.

4. Its durability, which is very considerable when the fibre is pure silk.

It takes coal-tar dyes with ease and exhibits a very great affinity for weighting materials of various kinds. So much is this the case that many so-called silk fabrics are composed chiefly of metallic weighting matters with a very small percentage of silk fibre. It is becoming increasingly recognised that excessive weighting spoils and tenders the silk, and so in the long run is detrimental to well-being of the trade.

Scroop.—When silk is passed through an acid bath (acetic acid) and afterwards dried, it gives out when handled a peculiar rustling, grating noise known as "Scroop."

Like all other textile fibres, silk absorbs moisture from the atmosphere without appearing very damp to the touch. As it is an expensive article, it is most important when purchasing to know that the legal limit (11 per cent.) of moisture in the fibre is not exceeded.

CHAPTER IV.

SILK WASTES.

THE term "silk waste" covers all classes of the raw silk which are unwindable and unsuited for the throwing process. The term "waste," understood in the general sense as conveying the idea of something worthless or of no use, is quite a misnomer. But, before the introduction of silk waste spinning, the refuse from the reeling and winding mills was indeed waste, there being at that time no use for it whatever, except for what could be combed and spun by distaff and spinning wheel, as still practised by peasantry in India and other Eastern countries. Considering that of all the silk spun by the silkworm more than half is useless for the throwster, it will readily be understood that there must have been a large accumulation of this material, and therefore a great future before an industry which could use up this so-called rubbish. Although there are a great many different grades and different classes of waste silk, there are really few distinct ways in which they are all produced, most, if not all, varieties being the waste from one or more of the following seven processes:—

METHODS OF WASTE PRODUCTION.—1. The silkworm commences to spin its cocoon by first fastening itself to the twig of a tree or between two leaves. Where the worm is reared by the peasants in their cottages or in filatures the peasants or attendants use straws, to which the worms attach themselves. All this silk is unwindable, coarse, and uneven, and consequently of no use to the throwster. Naturally this first waste is very much mixed with straw and leaves, and is of a dull, lustreless nature.

2. The cocoons are made up of layers of silk, and the outside ones, or the first spun by the worm, are too coarse and uneven for reeling, so the outer coating is stripped off and cast aside as waste.

3. As the silkworm nears the completion of its cocoon, the thread becomes finer and finer, insomuch that several of the last layers are made up of silk too fine to be strong enough to unwind, so that after the better or middle layers are reeled from the cocoon, the remaining part is discarded as useless for further reeling.

4. Among the cocoons there are some which are altogether unsuitable for reeling, included among which are the pierced cocoons. Although of no use for reeling, they are very acceptable to the silk waste spinner.

5. During the process of reeling from the cocoon into hanks or skeins, the silk sometimes breaks, and in consequence there is waste made by the attendant in finding the true and sound thread.

6. Waste is produced in reeling tsatlees into re-reels.

7. All the wastes produced in the throwster's mill, as described fully under the heading "Throwing."

Practically speaking, the various wastes are divided into two general classes: gum wastes and ordinary wastes. Gum wastes, whether Home, European, or Eastern, are really all throwsters' wastes, and are specially adapted for the making of yarns for lace, sewings, and weft purposes.

Qualities of wastes.—The best-known wastes are as follows:—

Steam waste.—The best known and most widely used silk waste in England is Canton filature waste, better known as steam waste. It is not a gum waste. There are two varieties, and several grades of each. The one which has generally found most favour with spinners is the "opened" waste, but, owing to its lending itself so easily to adulteration, spinners are now paying more attention to the "unopened" quality. Opened steam waste is the unopened waste pulled out by the natives, who work among it with their fingers and teeth, opening out the hard knubs which have been formed when the wet waste has been thrown down by the reeler, and allowed to dry and mat together, on account of the natural gum having hardened, which had previously been softened by the hot water in the basin attached to the reeling machine. Owing to the labour difficulty in China it is becoming more and more important that spinners accustom themselves to the use of unopened steam waste. There are really three grades of steam waste, which some years ago were known as "Selected," No. 1, and No. 2. But year by year the Chinaman seems to have got the better of the European silk inspector, and has let down the quality. In the "selected" he would leave a certain amount of No. 1, and in No. 1 he would put the No. 2, until at length the admixture of 1's and 2's was so much that No. 2 as a separate grade disappeared, all being mixed up with the No. 1, and passed as all No. 1. Naturally, the so-called "selected" got a greater percentage of No. 1, so that in time the European shippers decided to work up a better grade and call it "Extra selected." This latter came forward very nicely for a time; but gradually the Chinaman's cunning got the better of the inspector, with the result that he again lowered the quality of the so-called "extra selected," and therefore the "selected." This process was again repeated, and there came a grade known as "Extra extra selected" steam waste; but this was likewise doomed to the fate of the former changes, and to-day there is known what is called the "Extra extra extra selected" steam waste, which in point of fact is to-day not so good as the old well-known "selected," and the "extra extra selected" is a mixture of the old 1's and 2's. The deterioration goes on year after year, each succeeding year being worse than the preceding one, and each season showing a gradual falling away from the standard established at the commencement of the season. It is a lamentable state of affairs, but so far the Chinaman seems to have always managed to get the better of all the European inspectors; and so long as the present system of buying and passing of the waste is in vogue at Canton, so long will the Chinaman be able to hoodwink the inspectors.

Probably Chinaman is not entirely to blame. The steam Canton grade of silk on account of its freedom from hairs and vegetable fibres and its prized quality of lustre has become in great demand in the United States and also in Europe. As the quantity produced has not materially increased it naturally follows that the larger demand for the best grades has caused the exporters to increase the quantity of so-called higher grades by letting down the quality of such grades.

Frisons are cocoons with varying quantities of silk upon them which has been slightly pulled loose. Some qualities are full of wormy matter, but all are well liked by continental spinners for schapping.

Wadding, or blaze, which is also used almost exclusively on the Continent, is the first silk spun by the worm—that is, the silk which is wrapped around the twigs or straws and leaves, and is in consequence full of such vegetable matters when sold to the spinner. It is very heavily charged with gum, and consequently loses much when boiled off, and even then it is very inferior stuff. *Wadding* is a term also applied to silk which has been used as a packing inside the Chinaman's coat as a lining, and it may be of long fibre or otherwise. Frisons and cocoons are types which may come from all silk-producing countries. These wastes can be used for certain purposes without being discharged or degummed.

Tussah waste, exported from Shanghai, is of a dark brown colour, and is usually known as Newchwang Tussah waste and filature Tussah waste. They are marketed in two grades, *viz.* No. 1 and No. 2, which are packed in separate bales. Parcels of Newchwang are generally offered as 60 per cent. of No. 1 and 40 per cent. of No 2, and the filature as 50 per cent. of each, written respectively 60/40 and 50/50. There is also what is known as tussah throwster's waste, which, as the name implies, is the waste made during the process of throwing tussah raws. Besides the two qualities named above, there are other qualities of tussah waste shipped from China, but these two represent by far the bulk.

Nankin Buttons is a gum waste from the interior of China, of exceptionally good white colour and lustre. The bulk of it is long in staple, but it is always mixed with so-called buttons, which are really small portions of silk slightly matted together, and, a worse fault still, sometimes cut into half-an-inch to one-and-a-half-inch lengths. This waste is exported from Shanghai.

China wastes are from various sources, chiefly from English, French, and Italian throwsters. They are all long in staple. China soaped waste is from English and Scotch throwing mills. It feels soft, and its lustre has been hidden in the washing. French China is always bright, and not being weighted with soap often fetches a little more per pound than English silk. Italian and Swiss wastes are of the same nature as French wastes.

Shanghai waste is all gum waste, not quite so white as European silk, and harsher in feel. It is classed as fine white, fine yellow, coarse white, and coarse yellow. In the fine white are three well-known grades: Chintzah, which is the whitest and longest in staple; Hangchow, which is really a second picking or sorting over of the Chintzah grade, rather inferior in colour, not so long in staple, and more subject to twist waste and foreign matter; and the ordinary fine white, which is variable in colour, but good sound waste. The yellow varieties are produced in much smaller quantities, of similar qualities, but usually more mixed together, which really makes an inferior sort of article. Every sort is sold on its own merits;

some spinners use only coarse varieties, and others only fine.

Shanghai szechuen (or seychuen or sechuen) is a yellow waste, and the prefix Shanghai is to distinguish it from Canton waste of similar nature, sold as Canton szechuen. All Shanghai wastes were formerly offered as 1's, 2's and 3's. Some shippers now continue this, but the No. 3 being very small in quantity and low in quality, parcels are often offered now as 1's and 2's. As the No. 3 is, however, still produced in the East, spinners are suspicious that in many cases it is judiciously mixed with the No. 2 portion by the expert Chinese packers. However that may be, proportions are generally $\frac{75\%}{\text{No. 1}}$, $\frac{25\%}{\text{No. 2}}$; or $\frac{70\%}{\text{No. 1}}$, $\frac{30\%}{\text{No. 2}}$; or $\frac{60\%}{\text{No. 1}}$, $\frac{30}{\text{No. 2}}$, $\frac{10\%}{\text{No. 3}}$. All these grades are always packed separately.

Indian waste.—Of all the waste used by spinners, the Indian wastes (all gum wastes) are the most mixed and unreliable. The colour varies from grey to yellow, but there is by far the larger proportion of yellow. The fibre of some is as fine and clean as the best China and Japan silks, whilst others are coarser than the punjum waste. It is always subject to an admixture of bits of cotton, twist, black hairs, string, paper, etc.

Canton gum waste is very similar in appearance to the re-reel waste, but is not so reliable, and is very often more mixed with black hairs, cotton, hemp, etc. No. 2 gum is now a very scarce article in this country, spinners finding it too much mixed with rubbish, and hence too costly in picking, etc.

Re-reel waste is a Canton gum waste produced in the mills where the Canton raws are re-reeled, just in the same manner as Shanghai gum in the more northern districts; but the former is of a softer nature, and has more lustre—in fact, Cantons are the most lustrous of all silks, but are of a creamy shade. The silk of Canton gum and steam waste is spun by the same genus of worm.

Canton szechuen waste is a yellow gum waste with a good, bright colour, but apt to be greasy. The production is very limited, and it comes forward in little lots of 5, 10, or 15 bales.

Steam punjums are allied to both punjum waste and to steam waste. They are said to possess the virtues of both —*i.e.* they yield well and have the colour of steam, and they combine the lustre of punjum.

Punjum has peculiar characteristics of its own, and is supposed by many people to be the most lustrous of all silks. It is a stringy waste in appearance, and loses very heavily in boiling off—something like 50 per cent. It is reeled from cocoons, a number of ends together, and put into book form very similar to the tsatlees, as described under the heading "Tsatlee Reel" in "Raw Silk"; but owing to the admixture of rice water, in reeling process, or some such substance, the threads mat together, and are consequently unwindable. In this form the waste is known as punjum books, which are divided into grades 1's, 2's, 3's, and 4's—3's and 4's being the general run for English spinners, generally half-and-half. Punjum waste is produced in exactly the same manner, except that no attempt is made to run it into a moss; but, as an end breaks or runs off during reeling, the waste is thrown aside in a rough, tangled state. Of late years punjum books have been very largely used in India for weaving purposes and have consequently become too costly to use as waste in spinning mills.

China curlies are a well-known waste shipped from Shanghai, and the quality and appearance are more allied to steam waste than to any other variety shipped from Canton. It is a greyish-white waste, somewhat harsh to the feel. The name "curly" is given to this waste on account of its being so full of little patches of material matted together, which have a certain resemblance to a curl of hair. The waste is much in favour both in this country and on the Continent, and, as the crop is somewhat limited, many times the whole of the output is contracted for at the opening of the season. It is a commodity many speculators like to gamble with, the result being that many times, when the whole crop has been cornered, the price is many pence per pound over and above its value as compared with other classes of waste. Like most Shanghai wastes, curlies are to be had in several grades, but the No. 3 is so very inferior that few English spinners can afford to buy it, on account of the extra expense necessary in picking out the sticks, string, and refuse, to say nothing of the trouble caused in after processes by some of these objects having escaped the pickers in the first instance. Generally speaking, English spinners buy Extra Curlies and No. 1's finding even the No. 2's too much trouble in working; but there are shippers who import the proportions 60 per cent. No. 1, 30 per cent. No. 2, and 10 per cent. No. 3, written 60/30/10. Curlies were formerly shipped under a chop mark, the favourite being the "Yellow Pony" (or Peony), whilst such chops as the "Double Fighting Cock" and the "Gold Lion" are fairly well known. It must not be taken that *all* curlies are shipped under a chop mark, nor even that the best curlies have a particular name or trade mark. Some arrivals with no chop mark whatever are quite equal to any of the "Yellow Pony" chop; but, as a general rule, purchasers buying "to arrive" wish to have the chop stipulated at the time of purchase, as a kind of semi-guarantee of quality, as the various wastes from the different filatures have a certain reputation.

Shanghai long wastes are the most expensive wastes shipped from that port. They are to be had from various inland districts, and are known under the different names of such places, though there is a great similarity in appearance and not much difference in their qualities and yields. They have very much the appearance of knubs, but are tapey and very long. They yield exceedingly well, and are of a good light colour. The annual production is comparatively small, and very few spinners can use them to advantage, on account of their high price. For particular special yarns where strength and evenness of thread are absolutely essential, Shanghai long waste is used to advantage.

Japan wastes.—The best-known waste shipped from Yokohama is the Kikai Kibizzo, or Japan curlies. In appearance there is not much difference between this waste and China curlies, except that the former is generally of a better colour, and contains curls of larger size, longer staple, and consequently yields better. Japan wastes are more in request for continental spinners than for England, being well suited for the schapping in vogue there. Just like the China curlies, Kikai Kibizzo is shipped in three grades, but the principal buying for this country is for No. 1's alone, although at times parcels 60/30/10 are freely offered.

Iwashiro Noshi is another waste which is fairly well known here by the spinners who use the very best class of wastes. What the Shanghai long waste is to Shanghai, so is Iwashiro Noshi to Japan. They are very similar, except that the latter is a better colour, and just as Kikai Kibizzo will fetch a better price than China curlies, so is Iwashiro Noshi more valuable than Shanghai long waste. The production is very limited.

Noshito Joshiu or Tamas is practically the lowest class of Japan waste which is shipped for consumption in England for the ordinary spinner, but there are many lower varieties from Japan which are well suited for continental schappe spinners. Tamas are a stringy waste, not very good colour, and are subject to a certain amount of refuse. They are generally shipped in proportion 60/30/10.

Before passing on to European wastes, some details of the buying, inspecting, shipping, and landing of wastes from the East will not be without interest.

Buying.—As in most textile trades, so in the silk spinning industry, spinners must anticipate their requirements to a certain extent, and buy "to arrive," or "futures." This latter term is, however, seldom made use of in the silk trade. Comparatively speaking, very little waste is sent over here on account of the shippers, most of them preferring to buy against orders from brokers and merchants. The buying "to arrive" is done by the spinners through merchant brokers, who transmit the offers to Shanghai, Canton, or Yokohama, according to the kind of waste required; and the matter of quality is either fixed on certain standards which the merchant shows, or the spinner stipulates that it be equal to a certain shipment already had. In the absence of standards, the merchant undertakes to deliver the "season's average"—or, in other words, he contracts that his waste will be as good as the season affords, all due care being taken at the embarkation port that inferior waste is not shipped.

Terms.—The spinner buys on the "East India Company's Terms"—generally written "Company's Terms." It is understood, unless otherwise stipulated at the time of purchase, that the waste will be shipped from the port within four or six weeks after the placing of the order.

Inspecting.—The systems in vogue for inspecting at Canton, Shanghai, and Yokohama are very different, and much could be done in this respect to ensure better qualities and more uniformity in shipment, particularly so from Canton. In this latter place the shipper buys, say, a parcel of 50 bales of waste from a native dealer, who comes forward and tenders 50 bales already made up. The European inspector then picks out of the lot, wherever he may think fit, 3, 4, or 5 bales, and has them opened, and after examining them passes or rejects the parcel. If the lot is rejected, the Chinaman brings a further 50, which are subject to the same process, and so on until he has satisfied the inspector. It will be at once seen by one in the trade that this is a very lax method, for John Chinaman has these bales to sell, and sell them he will. If they are rejected by one inspector, he will tender them to another, in the hope that he may be lucky or unlucky enough to cause good bales out of the run to be opened, and so pass the lot. Very often the bales are made up in such a way that the outer coating of the layers of which the bales are made up are composed of really good silk, whilst the inside is cunningly made up of inferior waste. This is a common fault of Canton wastes of all descriptions. The only remedy seems to be that the waste be delivered in bulk to the shippers' go-downs, to be inspected by them in bulk, and packed by them just as is done in Shanghai and Yokohama, from which ports the waste is far more uniform and more reliable. The majority of the shippers at Canton say that it is impossible to do this in the case of Canton wastes, because they have not room in the European quarters to make go-downs in which to inspect the wastes.

Packing and shipping.—At Canton the wastes are all packed in small bales of one picul each (a picul is 133⅓ lb.), without press-packing, but they are well bound with cane, and the wrapping is matting. Shanghai wastes, which are packed under European supervision and in the shippers' own go-downs, are made up in three-to-four picul bales, and are press-packed. The Japan bales are very cumbersome, being packed similar to the Canton bales, except that instead of one-picul bales they come over in four-picul bales. Most Japan bales are, however, press-packed like the Shanghai bales. The shipping is, of course, undertaken by the European shippers out in the East, and, generally speaking, the documents covering the shipments are passed through the Eastern banks with a bill at four, five, or six months' sight, to be accepted here by the merchant and returned to the bank, which holds the waste until the bill is retired, when the merchant gets the necessary release order.

Landing.—On arrival in London, the waste is at once taken in hand by the Dock Company or wharfingers, and, immediately it is landed, the gross weights of each bale are carefully taken, and a certain number of each parcel tared, and the average tare of those taken is reckoned on the whole parcel. No. $\frac{1}{4}$ or $\frac{1}{2}$ lb. are reckoned: supposing the average tare is $8\frac{1}{4}$, $8\frac{1}{2}$, or $8\frac{3}{4}$ lb., the tare allowed is 9 lb. per bale, and any bale, weighing, say, $129\frac{3}{4}$ lb. gross, even though the average tare were $8\frac{1}{4}$ lb., would only be chargeable 120 lb. net. When the bales have been landed, lotted, and examined for damage, dock samples are drawn from every fifth or tenth bale according to request, and sent down to the buyer, and on receipt of these he must decide whether the quality is up to the standard on which he bought. Once having passed these impartial dock samples, he is held to have passed the waste, and has no claim for inferiority should he be disappointed with the waste when the bulk is delivered at his mill, unless he can prove some very flagrant case of false packing, and even then he must trust to the merchant from whom he bought.

European wastes.—Little need be said about the various qualities of these wastes, as all have very similar characteristics, and are practically, with the exception of the French and Italian knubs, the products of the silk-throwing mills, as described under the heading "Throwing." Knubs, however, are the long wastes produced in the filatures where the raw silk is wound from the cocoon, and have the same appearance and characteristics as the Shanghai long waste and Iwashiro Noshi, except that they are finer and of a more "classical" nature. These knubs are particularly in request by the continental spinners.

Of the many varieties of European wastes, the following are the best known: French China, Swiss China, Italian China, French mixed, Piedmont, and Spanish waste. *French China*, as its name implies, is the waste produced in the French throwing mills working China raw silk. *Swiss China* is the same produced in Switzerland; *Italian China* the same produced in Italy. *French mixed* is grey and yellow waste from the throwing mills, and is composed of Bengal, Canton, and Japan, as well as Italian and French wastes. It is somewhat subject to cotton, but is quite a favourite gum waste. *Piedmont waste*, as the name implies, is the fine Italian yellow waste made in the throwing mills producing organzines and trams from Piedmont raw silk. It is one of the most expensive yellow wastes, yielding very well, and producing a strong, lustrous yarn of a very elastic nature.

Terms.—These European wastes are not bought on what are known as "Company's Terms," but in the ordinary way of trade, the spinner getting credit, or at least getting the silk delivered before he pays for it, contrary to the custom with Eastern wastes. In this way he can ascertain, on the arrival of the bulk, whether it is up to sample or not. There are faults, however, which cannot easily be detected until the waste has been boiled or otherwise treated, so if he has any doubts about it at all, the spinner, immediately on arrival, takes steps to ascertain if it is free from twist or crape—*i.e.* hard twisted threads.

Given these brief notes on a few of the many varieties of silk waste, from which it will have been noted that the colour, the diameter of thread, and the packing are so varied as delivered to the spinner, and being also a much tangled mass of all lengths of fibre—some bales hard press-packed and other qualities loosely packed—it will be understood that preparatory to boiling or schapping—*i.e.* degumming—a certain amount of opening, sorting, and mixing will be absolutely necessary.

CHAPTER V.

THE PREPARATION OF SILK WASTE FOR DEGUMMING.

Opening bales.—All French, Swiss, Italian, and English silks are loosely packed, fine and coarse generally separate, so that in an ordinary way one would empty all the bags of the same quality and make a stack of waste of the same. Should it be necessary to mix white and yellow together, then a layer of white would be spread on the floor, and then a layer of yellow spread over this, in whatever proportion the spinner had decided the mixing should contain. The whiter the yarn required, the more white waste would be necessary in the mixing, and *vice versâ*. This process would be repeated until the whole of the waste required to complete the mixing had been added to the stack. In taking from this stack for boiling, care would have to be taken to see that the silk was most carefully drawn from the face of the bulk in even proportions from top to bottom, to ensure uniformity of colour in the subsequent processes. There is an alternative and better method to the above, which is adopted by some spinners. Instead of mixing the white and yellow wastes whilst in the gum state, each colour is boiled off separately, and then the boiled silk waste is put into the layers as described.

Steam wastes and most filature-produced wastes are fairly loose, and one-picul bales can either be taken singly and boiled entire, or a certain weight boiled, taking each bale just as it comes; or the waste can be sorted—that is, each layer of silk can be separated, the good waste taken off and put on one side, and the inside of the layer or bad waste put in another place, so that each quality can be boiled separately.

Press-packed bales of gum waste from Shanghai and wastes from Japan are very troublesome, Shanghai wastes particularly so. After taring these bales, they are laid on the floor edge up, wooden wedges are driven betwixt the layers of silk, and they are thus split asunder. Water run between the layers will quickly so loosen the waste that it is easily pulled into small portions.

Gum Softening.

Gum.—There are two principal ways in which silk waste is freed or partially freed of its natural gum or sericin. The *English method* known as *boiling* or *discharging* is conducted at high temperatures commonly known as boiling but reaching well over 300° F. It is desired to remove all the sericin from the fibroin, but unfortunately the excessive heat often splits the fibre and considerably weakens it, causing eventually weak yarns.

The *continental process* is known as "schapping," in which process the gum is loosened by natural fermentation conducted at low temperatures very considerably below boiling point and is designed to thoroughly soften the sericin without doing any injury to the fibroin.

Water.—No matter which process is adopted, the first and most important question is the water available. This should be very soft, and free from iron and carbonates and silicates of lime. The objections to these compounds are on account of the tendency, in the case of the iron, to discolour the silk, and the limes decompose the soap which may be used, as the alkali in the soap unites with the carbonic and sulphuric acids of the limes, thus leaving the fatty matter of the soap free to combine with the lime, and form an insoluble pasty, greasy substance which has no washing or cleansing properties. In fact, it adheres to the fibre, and makes the gum and dirt more difficult to remove; and when the silk is taken from the water, and dried, the precipitate is hardened in the thread, causing it to feel gritty and to be dull in appearance. The gritty substance is even carried forward through several processes, damaging drawing rollers and leathers. The harder the water the more soap is necessary; so it is well worth the attention of the silk spinner to take the trouble to have his water carefully analysed, and if found hard to take steps to soften it.

Soap.—The question of soft water having been determined, the next matter which requires the spinner's attention is the soap to be used. Alkalies eat into the silk fibre and render it tender and brittle; so, to minimise this effect, it is necessary to soften the effect of the alkali somewhat, and this is best done by means of the fatty matters contained in a white mild curd soap.

A soft soap will degum easily and without damage to the fibre, but the potash in the soap appears to have a discolouring effect on white silks. The oily nature of the soap causes it to adhere closely to the silk, sometimes rendering it greasy and cloggy and difficult to work in after processes. On coarse, harsh silk, like tussah, such a soap can be used to advantage, as it improves the feel of the silk. A good curd soap is expensive, and in times of cutting prices it is a great temptation to endeavour to save money by buying a cheap and consequently inferior article. This is a game of "penny wise, pound foolish." The soap may appear to degum all right, the silk may go through its next process fairly well, and the drawing over-looker only finds out something is wrong when his waste from slivers and fly increases very materially. The silk when in that department has increased in cost from its first (purchased) price by four or five times, being worth from 4s. to 18s. per pound, and sometimes more; and as soap of first-class quality is 5d. to 6d. per pound, and poor soap costs 3d. to 4d. per pound, the saving in first cost is soon lost, with heavy interest, if silk is lost in waste after it has been through one or two processes. A good white curd soap should show at least

64	per cent. of fatty matters,	with about
25	,,	water and
11	,,	alkalies, etc.

The greater the percentage of fatty matter, the less soap will be required for any quality of silk; and as it is the fatty matter which is the costliest ingredient in soap, it is obvious that adulteration would mean a less percentage of fat, which means more soap will be needed for a specific quantity of silk. Then, again, the nature of most adulterations is particularly injurious to silk, and very few more so than silicate of soda, which, whilst assisting materially in bleaching silk, will at the same time dull it, make it feel harsh, and cause it to work short in dressing frames. The sand or powdered quartz in silicate of soda appears to stick to the silk fibre in spite of all attempts to wash it off, and although the particles are most minute they can and do, cut the silk very much. The presence of this injurious mixture can often be detected by taking a portion of boiled silk, drying it thoroughly, and then shaking it well, when a white powder will fall from it, which on examination shows hard particles and is quite gritty to the touch. Much of it will not shake off, and is carried forward through the various following processes, and acts exactly in the same manner as lime soap. A cheap soap of course always contains a large percentage of water, which commodity the spinner is quite well able to put in for himself, without paying so much for it as when sold as soap.

For the sake of economy many experiments have been made, with a view to degumming by means of caustic soda or caustic potash alone, used in small quanties in cold or lukewarm water, which mixture softens the gum, which is then washed off with clean water or soap and water. These experiments have not, however, been found satisfactory, because the caustics are so strong that when they have loosened the gum, so that it will easily wash off, they have also attacked the fibre itself and burned it considerably. Various means of counteracting the action of the caustic on the fibre have been tested, and some perfected, in the chemist's laboratory, but none have been put to practical use.

During last few years certain soap makers have made flake soaps which are supposed to contain less water than ordinary hard soaps, and are therefore more economical.

CHAPTER VI.

SILK WASTE DEGUMMING.

Schapping.—If gum silk, or so-called silk waste is piled in a heap in a damp warm place, and kept constantly moist, the gum will begin to ferment and loosen. By continually turning over the pile all portions of the heap are properly softened, but the process takes several days, much depending on the quality of the silk being treated. The method

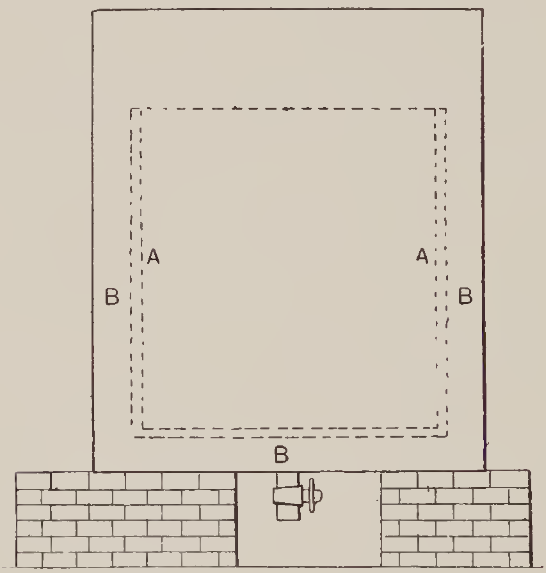


Fig. 18.—Schapping vat.

is too long and the stench from the fermenting matter too great to allow of such being much practised in England; and on the Continent, where schapping is in vogue, a much quicker method is adopted. A cistern of wood (Fig. 18) measuring about 6 ft. in depth and 5 ft. diameter, is fitted inside with a wooden cage (shown by dotted lines A), allowing 4 in. space B between the outside measurements of the one and inside of the other. The top of the inner cage is about 15 in. below the height of the outer cistern. The former is perforated bottom and sides with 1 in. holes, about 4 in. apart, to allow water to circulate freely from outer to inner cage. A steampipe is fixed to enable the water to be kept at the required temperature. The water for use must be well softened, and it is well that it should have been boiled. When the cistern is empty, about 30 lb. of silk is laid in the inside cage; some water is then run in, and the silk well beaten down until it is thoroughly saturated. Another 30 lb. of silk is then placed in, well trodden down, saturated with water, and the process repeated until the inner cage is full. Some boards are then placed on the silk, and heavy weights placed on them to hold down the silk, which is disposed to swell and to rise out of the water. When well weighted down the cistern is filled up with water to 8 or 10 in. above the boards, and the temperature kept at about 140° F. until the operation is complete. This will take from two to six days, according to the quality of silk under treatment. At the expiration of two days a string of silk is taken out and rubbed well between finger and thumb nail and then broken, and if the silk shows fine fibres at the broken ends it is soft enough, or degummed sufficiently, for the next process. If, on the contrary, hard ends show, the silk is kept in the cistern longer, and the test made every day until it is softened enough. In place of wooden cisterns it is now most usual to use large kiers which can be hermetically closed. On removing from these kiers it is sometimes advisable to put it into a hydro extractor for the purpose of getting out as much dirty and gummy liquor as possible. Afterwards the silk is placed into shallow wooden tanks with water heated to about 180° F., and kept at this temperature for some time, so that the loose gum can be easily washed off. Or the silk is placed in shallow circular machines (Fig. 19) which are revolved slowly, and at the same time a stream of water injected into the machine, thus washing the loose gum thoroughly off the fibre, whilst the beaters or stampers keep the waste soft and pliable and help to loosen the gum. Some silks, such as cocoons, will swell exceedingly in the first degumming liquor, and have to be continually beaten and trodden by the attendants' bare feet to ensure their being saturated

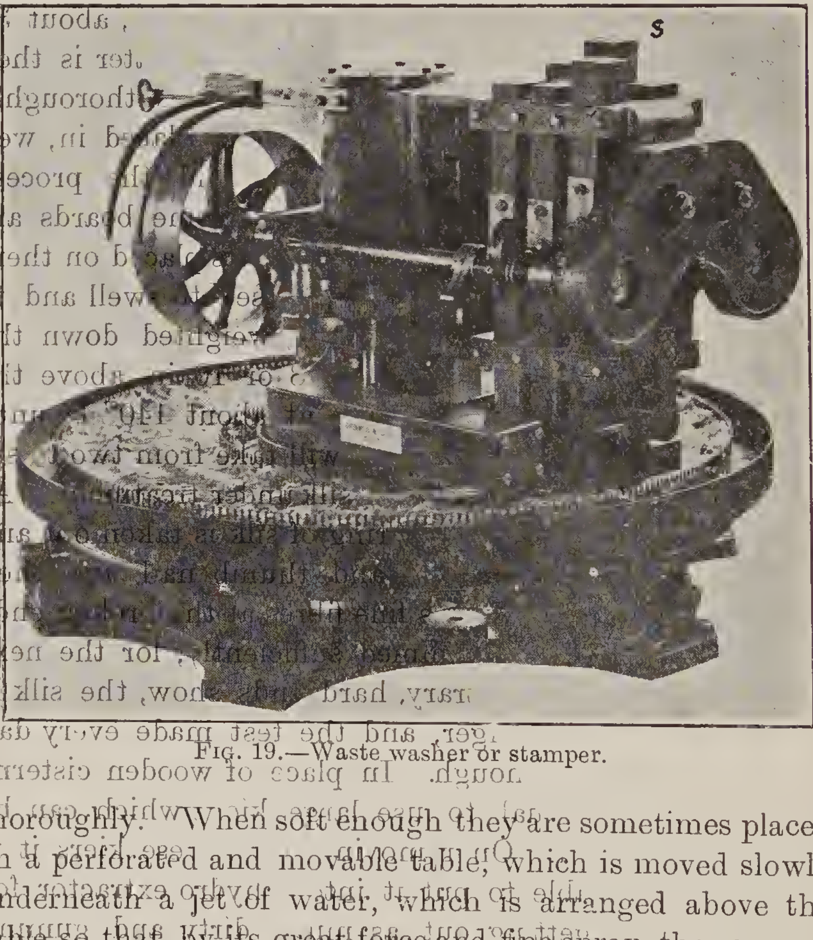


FIG. 19.—Waste washer or stamper.

thoroughly. When soft enough they are sometimes placed on a perforated and movable table, which is moved slowly underneath a jet of water, which is arranged above the table so that, by its great force and fine spray, the cocoons, or silk, are exceeding well washed, to free them from dirt and all loose gum. After the silk has been under the spray for some time it is turned over, so that what was underneath comes uppermost under the tap for the washing, which is repeated. Much experience and skill are necessary to be proficient in all these processes, and every operation needs most careful supervision—water testing for heat and softness, repeated testing of the silk to ascertain if it is softening satisfactorily, etc. Any slackness or inattention to any of these details may result in the silk being inadequately schapped, and if the silk is allowed to pass, although not satisfactory, much trouble may be caused in the after processes, and the yarn spoiled. After the washing, the silk must be dried, beaten, and conditioned.

The silks most in favour for schapping are Japan wastes, China curlies, knubs of all sorts, and cocoons of all descriptions. Gum wastes are more difficult, because by the nature of their production they are subject to hard ends—*i.e.* twisted threads—which do not lend themselves to the softening process. Steam wastes need care because, although they do not contain hard ends, they are so matted in hard lumps that they soften in a very irregular manner, and whilst some portions might be exceedingly well schapped, the next portion may be hard and gummy. For schappe yarns it is fairly safe to assume that the cheaper the yarn the more gum the buyer is purchasing. A first-class white schappe contains only 1 to 2½ per cent. of gum, and it is obvious that a great deal of skill and attention has been necessary to enable the spinner to produce such a yarn. Other yarns can be bought which contain up to 25 per cent. of gum.

Boiling or discharging.—These are the names given to the processes by means of which *all* the gum is boiled off the silk fibre; and the methods of doing so, whilst varying very much in detail, follow two main ideas or principles. One is to subject the silk to boiling liquors of water and soap, and so get rid of the gum as quickly as possible; and the other is to soak the silk in hot liquors, and do as little boiling as is possible consistent with a thorough discharge of the gumming matter. The boiling cisterns used to be made of copper, but of late years wooden ones have become very popular. Fig. 20 is a sectional drawing showing the construction of these boiling tubs, as they are called, and two of them are usually placed side by side for convenience in working. A is the outer casing of wood; B is a perforated iron false bottom, perforated to allow steam to issue from pipe S, which is coiled round the tub bottom; W is a water pipe; C is an outlet pipe, which discharges into the drain D; and F is the floor level. The tubs are 6 ft. deep by 4½ ft. diameter.

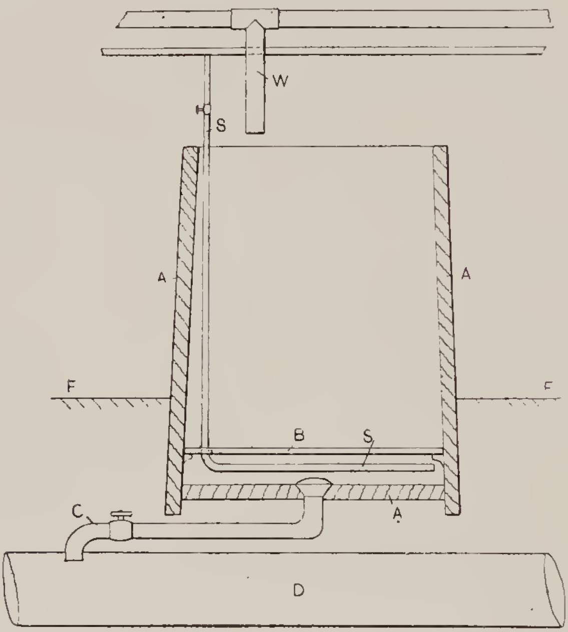


FIG. 20.—Boiling tub.

Boiling in bags.—This refers to the placing of the silk waste into strong open-meshed cotton bags, measuring about 16 by 10 in. From 12 to 16 oz. of silk are put into one bag, after the waste has been well opened and loosened by the "bagger." It is put in the bag in as bulky a condition as possible, and the mouth tied very securely with cotton tape to prevent the contents dropping out during the boiling process. It is very important that only small quantities be placed into one bag, so that there be plenty of room for the silk to swell. The mesh of the bags should be about $\frac{1}{4}$ in., so as to allow the water to circulate freely. It is an important matter that there should be periodical examination of these bags, because the constant wear and tear result in their being torn, the silk thus dropping out of the larger holes ; and, again, the bags shrink so much with continuous boiling and immersions in hot liquors that in time the mesh becomes very close, water percolates with difficulty, and the result is that the silk is not properly discharged or degummed.

Boiling.—For the boiling tub described above, 100 to 120 lb. of silk is placed into bags. Before putting these bags in the tub the boiling liquor has been prepared. About 18 to 24 in. of water has been run in, about 12 lb. of white curd soap has been added in thin shreds, the water then brought to boiling point, the soap melted, and the whole allowed to cool down to 180° F. The bags of

FIG. 21.—Rake.

silk are then thrown in, and at the same time carefully pushed under the liquor by the help of a pole until they become so saturated that they remain under of their own accord. When the whole 100 to 120 lb. has been put in, the bags will nearly have filled the tub, and the liquor will just cover them ; then the steam is turned on, and as the water boils the bags are turned over and over by the action of the steam, so becoming boiled in all parts alike. The attendant must see that the bags are on the move, and by means of his pole, or the wrought-iron fork shown in Fig. 21, must push the bags always under water which is to ensure every portion of silk being thoroughly degummed. If constant slow boiling is not kept up, the portion of silk forming the centre of the bag retains some gummy matter which is very detrimental in after processes ; or the waste may be discharged, but the centre retains a quantity of yellow colouring which does not wash away.

A thoroughly good attendant will see that the waste becomes thoroughly saturated with the soapy liquor and that the soap foam entirely covers the silk throughout the time occupied in boiling. The first boiling should occupy from $1\frac{1}{2}$ to 2 hours, when steam is turned off and the liquor allowed to run away, the silk being then removed and taken to the hydro extractor, Figs. 22 and 23. These are strongly constructed, and the cage A is best made of copper. The material is placed inside this cage and the machine set in motion, when the centrifugal force and air current drives the water out through the sides of the revolving wire cage, against the stationary strong iron sides of the outer cage B, whence it escapes at the outlet C.

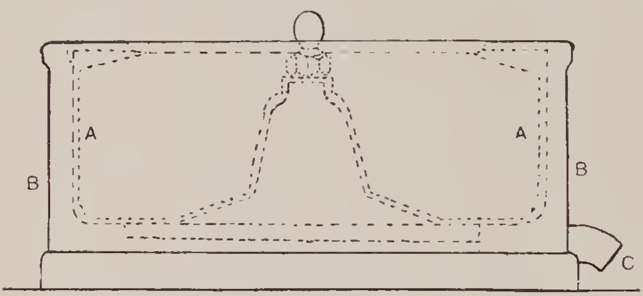


FIG. 22.—Hydro extractor (side elevation).

This semi-drying process gets rid of the gummy, dirty liquor from the silk out of its first boil. Another way of achieving the same result is by means of a mangle machine, Fig. 24, through which the silk is run, two or three bags side by side. The top roller is held by strong springs operated by hand-wheels. Some spinners are very fond of this squeezing of the silk, and doubtless when the lot is full of cocoons containing the worm and chrysalis, the mangle is a means of crushing these deleterious matters. It is also thought by some to put a lustre into the silk not obtained by the hydro extractor. At the same time the mangle causes a slight discoloration of fibre if used on wormy wastes. Again, some qualities of silk are lifted out of the boiling tub on to a wooden grid placed on the top of the tub, and allowed to remain there some time, whilst the liquor gradually drips back into the tub. Meanwhile a second tub has been half filled with water, about 15 lb. of soap dissolved in it, and the whole boiled and allowed to cool as before. The waste previously treated

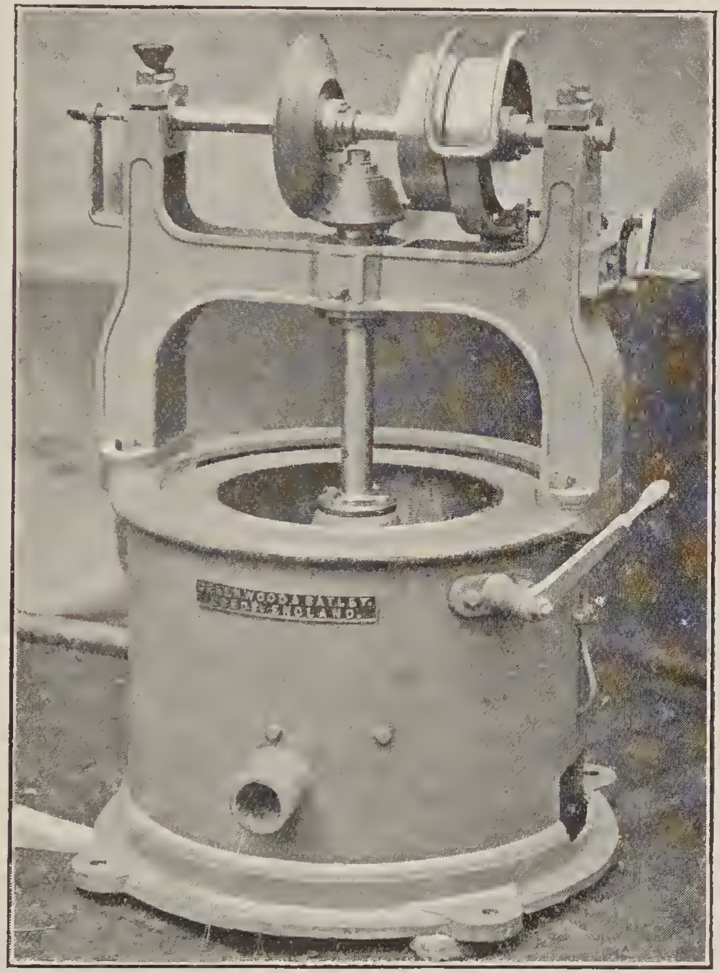


FIG. 23.—Hydro extractor.

is now put into the second tub, and re-boiled from 1 to 1½ hour, all the time being constantly watched as in the first bath. It is then taken out, and in some cases immediately placed in the hydro extractor and dried as much as possible; in other cases the silk is placed in clean hot water at about 180° F., well rinsed from soap, and then dried.

Some spinners like the silk to be a little soapy when finished, and others take just as much trouble to wash the soap out. One class say the soap feeds the silk and helps it to work long, whilst the other class say the soap makes the silk work greasy, cloggy, and dull. Probably they are both right in their respective mills, the difference in the treatment arising more from the difference in the water and soap used than anything else. The liquor in the second boiling tub is saved and used for another boil, *but*

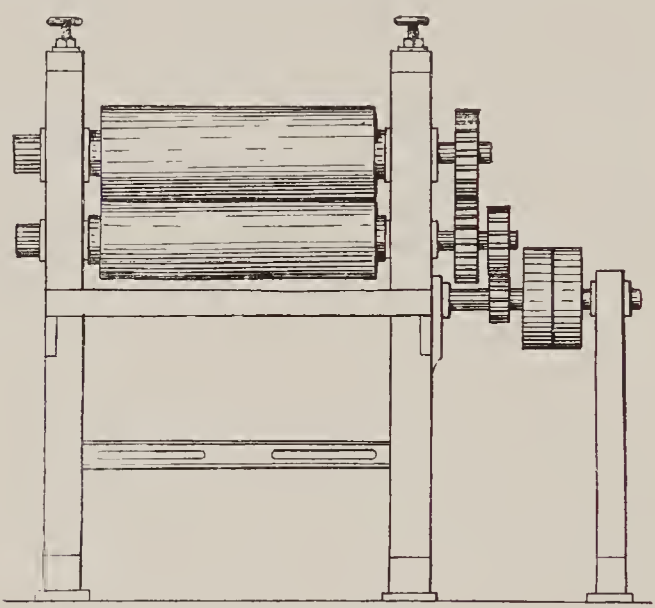


FIG. 24.—Mangle.

as a first boil only; and in place of using 12 lb. of soap, only 8 lb. need be used, as sufficient soapy matter is left in the liquor of the second boil to make the addition of 8 lb. of soap quite enough to ensure a proper degumming.

The first boil is for the purpose of thoroughly softening the gum, and when properly done the silk feels soft and very slimy. The after processes are to wash off the gum, and at the same time to bleach the fibre. For many qualities of silk wastes some spinners do not boil the silk in the first instance. Instead, they omit bagging the silk and put 100 to 120 lb. into the tub, and press it well down, somewhat after the manner described in schapping, and allow the silk to remain in the soapy liquor 6 to 10 hours at 180° F. The gum is then found to be well softened, and the silk ready for putting into a second bath and therein boiled. Never under any circumstances should the silk be placed in water which is *boiling*. This would, particularly in the second boil, fasten the dirt and colour into the fibre. The boil should not be of a violent nature, as it would blow or disintegrate the silk fibre. Very violent boiling, coupled with an excess of alkali, will spoil the fibre, and if then a brin of such silk be examined under a powerful microscope it will be seen that it presents the

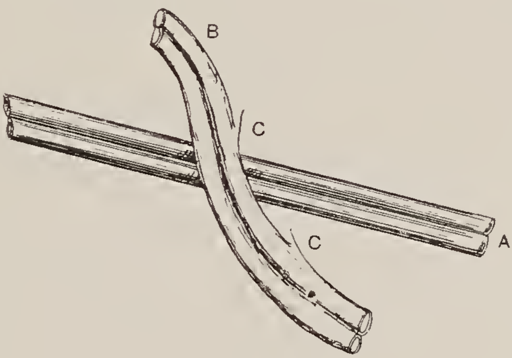


FIG. 25.—Brins.

appearance of having little projections from the thread, as if the fibre had split. Fig. 25 shows this appearance better than words can describe it. A is a brin of silk properly boiled ; B, a brin too much boiled ; and at C the fibre is shown broken. This fault makes the silk very tender ; it will not spin to as fine a count as it ought, and in the various drawing processes a great deal too much waste is caused.

After being once used, the soap baths are often sold to dyers, and are known as boiled-off or gum liquor. They are valued on account of the gum and fatty matters in the liquid, and are used for dyeing purposes, the gum adding lustre to dyed silks. A great deal, however, of the boiled-off liquor finds its way into the nearest brook or river, thus polluting it to some extent. It is possible that legislation will in time compel all spinners to turn out their waste liquors in a state of purity. Some have already had to erect press filter plants to recover soap from the liquor and managed to make a satisfactory and fairly economical business of it.

Recipes for boiling.—The following recipes for silk boiling will be found of great service. The soap must be of good quality and the water very soft, or the proportions of soap used, and even the time occupied in boiling, will have to be altered:—

Quality.	Weight in Gum.	First Boil.			Second Boil.		
		Time.	Soap.	Chemicals.	Time.	Soap.	Chemicals.
	lbs.	Mins.	lbs.	lbs.	Mins.	lbs.	lbs.
Home China	120	60	9	...	90	11	...
Italian, French, and Swiss gum wastes . . .	120	120	18	...	150	16	...
Canton gum and steam wastes	120	80	10	...	75	12	...
Curlies, knubs, and kikai .	100	60	10	...	60	10	...
Shanghai, punjum books and waste	120	90	11	2	60	15	...
Indian wastes . . .	100	60	12	...	60	12	...
Tussah knubs and throwsters' waste	100	90	10	4	60	12	...
Tussah cocoons . . .	100	120	13	6	80	7	4

The chemicals are salts of tartar. If a specially white yarn is required, made from China wastes, half a thimbleful of No. 1 Blue is put into the second boiling liquor. This takes away the slight cream tone, which is really the natural colour of silk. It will be noticed that home China waste takes much less soap than Italian, French, and Swiss China. The reason for this is, that home China waste (English thrown) is soapy, whereas the continental is not. The gum of foreign thrown waste also takes a lot more softening than the English, very often caused by the addition of greasy compounds to raw silk prior to winding, etc., hence the longer time occupied in boiling; the alkali in the soap used by home throwsters has slightly softened the gum, because the waste has usually been lying in a heap some months. In boiling-off white gum wastes of English and continental origin it is not absolutely necessary to have two boilings, one being quite sufficient if done in the following manner: Run water in the boiling tub to a depth of about 36 in., add 10 lb. of soap, heat until the soap is dissolved, and then put in 100 lb. of silk in bags. Allow them to remain in for 1 hour at about 160° F., then add 15 lb. of soap which has previously been dissolved. Boil the silk for 2½ hours if continental, and for 1 hour if English. The silk is then taken out and put through the hydro extractor in the usual way.

Steam, curlies, knubs, and kikai classes of wastes need putting through rollers, or into the hydro extractor, between the first and second boils. All wastes which contain chrysalis, as kikai and curlies, want careful treating in the first boil in order to get them well softened, and should then be well washed to get rid of the dirty-coloured liquor caused by the chrysalis. If the wastes are put straight from the first boil into the second boil, they hold a large quantity of discoloured water which stains the waste and is practically boiled into the waste by the second boiling, which is thus made to act practically as a dyeing liquor. Very dusty wastes, like the Indian variety, require a preliminary wash before the first boil, and a good way is to prepare an ammonia bath—a shallow wooden tank full of water into which a pint or two of ammonia has been added. The waste is then rinsed through this bath, the ammonia killing the grease and dirt in a wonderful way, and allowing the soap in the first boiling to play immediately on the silk to degum it. The colour of waste treated in this way is usually much clearer and whiter than it would be if boiled off without the preliminary bath.

Each class of waste requires careful study and supervision to gain a knowledge of what is the best process and the most suitable water and soaps. These differ so much in various districts that a process which will suit one spinner might have to be altered very materially to suit the conditions in another district. Silk boiling and schapping are most important processes, and ought to be conducted by intelligent and skilled workmen. After they have done their part, the resulting silk needs careful inspection day by day, and any waste not properly boiled or schapped taken out and redone.

Boiling without bags.—Many spinners dispense entirely with the use of bags, placing the silk waste direct into tubs in weights from 100 lb. upwards, and adopt various means for mechanically handling the much tangled wet mass after boiling.

Ether and soap foam.—Boiling experiments of late years have been fairly numerous, and patents have been filed covering use of certain ferments, pancreatine and the like and use of soap and alkaline foams and also degumming by use of ether. If the latter process could be developed economically, and at same time enable the gum to be separated and made fit for commercial use, all other methods known up to date would probably be displaced.

Drying.—After boiling, washing off, and treatment in the hydro extractor, the silk is taken, by means of skips on wheels or trucks, to a stove or drying machine. The stove is very often a room partitioned off from the boilers; or, if that is not convenient, a room near the washhouse is used, being converted into a stove by means of a coil of steampipes along the floor. Posts are erected at distances of 2 to 3 ft. apart, and cross beams affixed to them, on which are placed small galvanised hooks. The silk is hung on these hooks and allowed to remain in the room until thoroughly dry, or latticed stages are erected round the room, and the silk placed on them until dry.

Air should be kept in constant circulation to obtain the

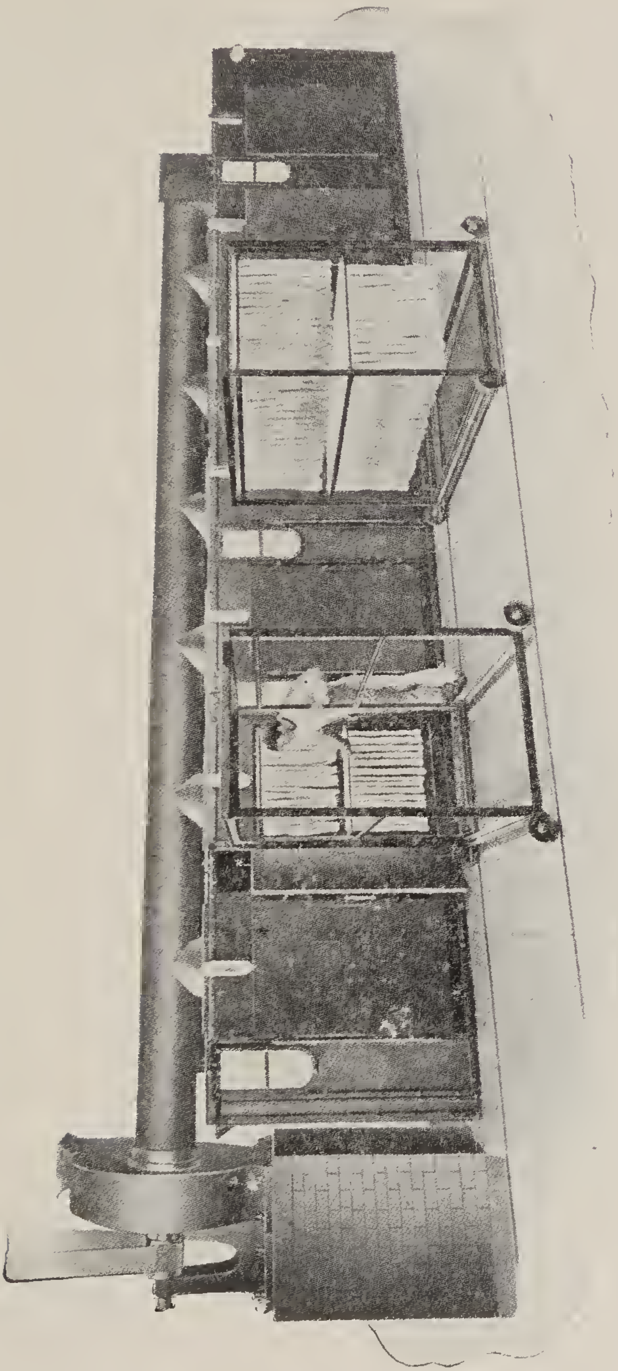


Fig. 26.—Drying machine (Tomlinson-Haas).

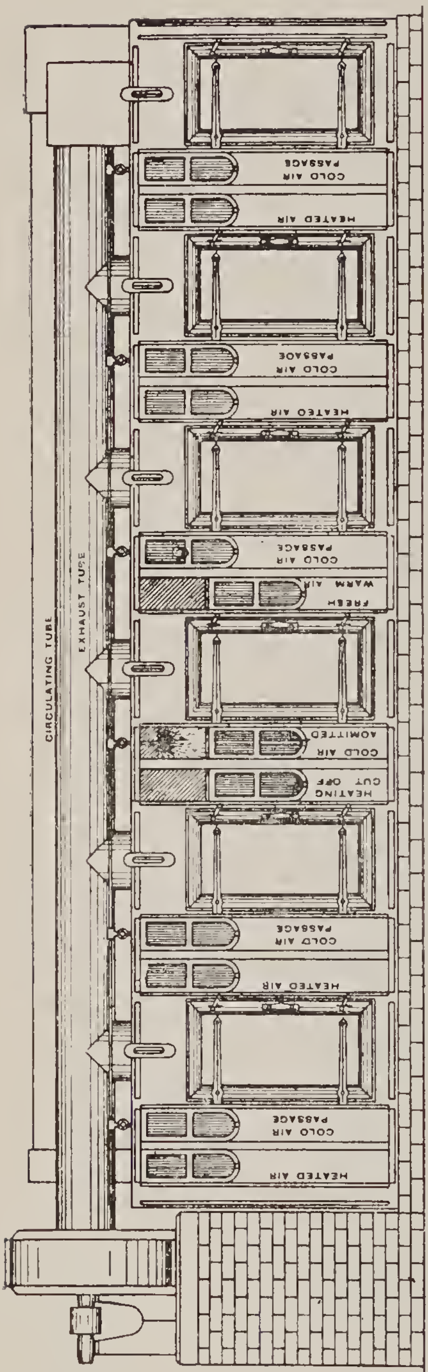


Fig. 27.—Drying machine (Tomlinson-Haas).

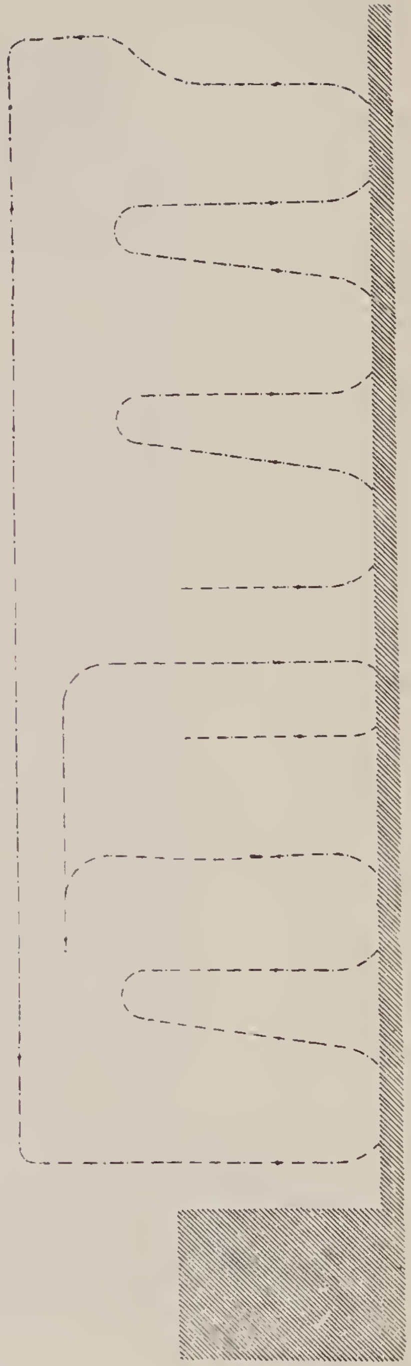


Fig. 28.—Drying machine (Tomlinson-Haas).

best results in the shortest time. The silk should be well opened to ensure best possible results.

Drying by mechanical means.—In order to economise in labour and obtain large weights of silk dried per day,

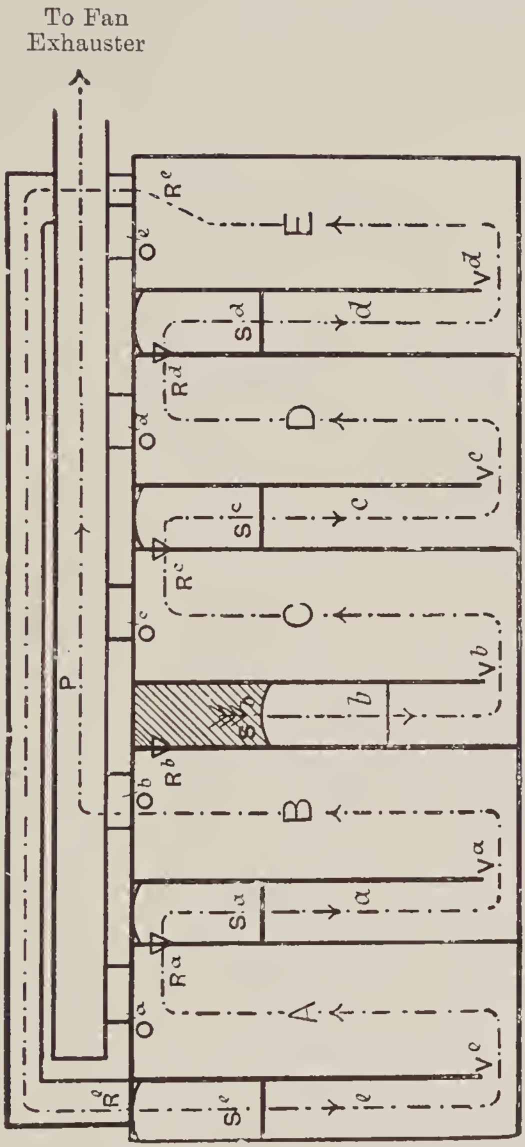


Fig. 29.

some spinners use drying machines of which the most successful is the Tomlinson Haas type, Figs. 26, 27, 28, 29, illustrates this machine.

In the heating compartments (*e*, *a*, *b*, *c*, *d*) the air passes over steam pipes, thereby increasing its temperature. In the drying chambers (A, B, C, D, E) the air passes through the material from the lower to the higher, absorbs the moisture and carries it away.

The drying air, which is drawn through the machine by a fan at the end of pipe P is always passing the whole of the drying chambers and heating compartments in a complete circle.

The air inlet is at one of the heating compartments by one of the valves S (*e*, *a*, *b*, *c*, *d*). The air outlet is at one of the drying chambers by one of the valves O (*a*, *b*, *c*, *d*, *e*). These two valves and the one between them R (*a*, *b*, *c*, *d*,*e*) are connected and act automatically; for instance, when S *b* is opened for the air inlet, O *b* opens automatically for the air outlet, and R *b* closes the connection between B and *b*. The way the air must take is therefore as shown by the dotted line.

As the workman empties and refills the chambers from the left to the right, it follows that each succeeding one he opens will be the driest, the next a little wetter, and so on, and the last chamber on the left will be the wettest.

In the diagram above, chamber C is the driest. It receives the dry air, which enters the machine from the atmosphere by valve S *b*, into the heating compartment *b*, and is consequently only once heated. Before the air enters chamber D it is heated again, so that two heating compartments are acting upon the material which is relatively wetter, and so on, chamber E receiving the heat of three chambers, A receiving that of four, and chamber B (which has just been filled in and contains the wettest material) receiving the heat of five heating compartments. The dry material of chamber C is now removed and wet material takes its place. Chamber D now becomes the driest and C the wettest.

In order to maintain the same graduated circle of air, the workman closes S *b* and opens S *c*. With S *b*, O *b* closes and R *b* opens automatically, and with S *c*, O *c* opens and R *c* closes automatically, the air entering at S *c* and leaving the machine at O *c*. Chamber D, being the driest, now receives the heat of only one compartment, while chamber C, being the wettest, receives that of all five heating compartments. So the workman goes on all day, emptying and refilling the chambers, closing the valve on the left, and opening the one on the right, this being his whole work.

It is easy to see that by this method of quick drying it is impossible to spoil the material or, on the other hand, to waste any steam, as all is absolutely used for drying.

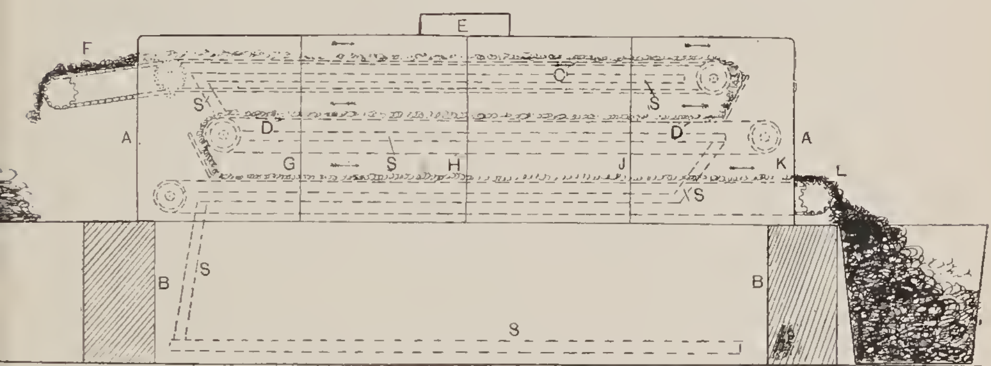


FIG. 30.—Drying machine.

In addition to drying the machine is also able to condition material with once handling, an advantage that cannot be ignored in these days of keen competition.

Another system is to use one of the numerous drying machines, of the type illustrated by Fig. 30. A is the outer frame, and G, H, J, K represent four sections into which the machine is divided for convenience of looking into the apparatus if anything goes wrong. B is a space provided to draw in fresh cold air, or it can be utilised by putting in a tubular heater and fan, and so forcing air to the top of the machine to the outlet E. This outlet in the machine shown is provided with an exhaust fan, and draws hot air from the bottom of the machine through the silk, so keeping the material light and loose. The wet silk M is fed into the machine at F, and carried forward by means of a latticed chain C to end, when the silk drops on to the second latticed chain D, that portion of material which was uppermost now being underneath, and is thus carried forward and dropped again on the third chain, and thence to the outlet L. Some machines are made with five or seven sets of latticed chains in place of the three illustrated. S are steampipes for heating the chamber.

One of the advantages of a machine is, that it can be placed at one end of the washhouse or near to that estalishment, so that the silk is not carried out of doors to the drying place. In cold weather silk should not be allowed to be chilled in transit from the finishing liquor to the hydro, or from thence to the stove. Frost and cold winds damage the fibre very much, making it harsh and tender.

Drying appears to be a very simple process. The ordinary workman thinks it only necessary to take the silk and hang it on the hooks in the stove, or put it in the drawer of the drying machine, for the heat to do the rest. This is a great mistake. Bad drying means irregular drying—too much or too little, which are equally deleterious. If a stove is used, the silk needs hanging on the hook—not in a big lump, the centre of which retains moisture after the outside is dry; but the portion hung should be pulled and opened, to make it hang as lightly and loosely as possible, so that the hot air can circulate freely through the silk, so drying all portions of it. When placed in a drawer, it should be spread lightly and evenly, and then the result is a nice lofty silk, whether stove-dried or machine-dried. It must be thoroughly dry, or it will not "condition" properly afterwards. After drying it is usual to weigh the silk, in order to see what percentage of gum is on the fibre or what percentage of gum has been boiled off; and this is important to watch, because of its effect in regulating the price or value of the silk in the gum, and a proper record should be kept and examined from time to time, in order to see that the qualities are not deteriorating or having additions made to the natural gum by the natives in the East.

PERCENTAGE OF GUM LOST IN BOILING.—Appended is a list showing the approximate amount lost in discharging various wastes :—

Quality.	Weight to Boil.	Weight from Stove.
	lbs.	lbs.
Home China	100	66 to 69
Foreign China	,,	70 ,, 75
Canton gum	,,	70 ,, 72
Steam waste knubs	,,	50 ,, 62
Curlies and kikai	,,	60 ,, 70
Fine Shanghai	,,	69 ,, 72
Coarse Shanghai	,,	68 ,, 70
Indian wastes	,,	64 ,, 70
Punjum books	,,	52 ,, 55
Tussah	,,	66 ,, 80

It will readily be understood how vital a point is the loss in boiling when one considers that raw waste in year 1917 costs from 2s. 6d. to 7s. 6d. per pound, so that the cost of the discharged waste is augmented or decreased in accordance with the loss, and *vice versâ*. The value of the raw material is proportionate to the yield after boiling. The loss on all classes of waste is important, for no matter if the quality be low, an extra 2 or 3 per cent. loss in the boiling increases the cost of the yarn made from it and goes to reduce the margin, which on lower quality yarns is, generally speaking, correspondingly less. It is not a sufficient test to simply take the weight of silk returned from the stove, as the degree of dryness may vary at different times, being better dried on some occasions than others. It is essential that systematic tests be made from time to time, by taking 10 lb. of gum silk made up from ten separate bales, 1 lb. from each, carefully weighed to fractions of an ounce, which is sent to the stove to be dried, say, for twenty-four hours, when the waste is weighed and the loss carefully noted. This treatment is repeated several times until it will lose no more by drying. To the net result add 11 per cent., which is the natural moisture in silk, and is the recognised legal proportion allowed. The weight now arrived at is the natural weight of the silk. Have the silk boiled along with an ordinary boil, specially marking the bags containing the dried silk, so that, when discharged, these particular bags can be sorted out and the silk taken from them and dried in the same manner as described above, until it will lose no more by drying; then add 11 per cent., and from this the exact loss in boiling off can be ascertained. Example:—

Waste in the gum taken from the bales, 10 lb.	Dry weight . . .	9·0 lb.
	Plus 11 per cent . .	0·99
	Natural weight .	9·99
Suppose resulting boiling off be 7 lb., then tinder dry	.	6·87 lb.
	Plus 11 per cent . .	0·75
		7·62

Deduct from 9·99 lb.
7·62

2·37 lb. loss on 9·99 lb. = 23·72 per cent.

If a record be kept of these trials, and also of the daily results from the stove, any unusual loss will be quickly noticed, and steps can be taken to find out the reason and prevent further loss. The records also show if the boils are being properly dried in the stove. If it be that the waste has deteriorated—which is many times the case—the spinner must not lose sight of the fact that he must buy at a proportionately lower price, or replace it by other qualities which yield what he requires.

Home China wastes require watching very carefully, as the different throwsters may put a greater percentage of soap in their waste, to say nothing of the extra so-called "conditioning." It naturally follows that damp waste will yield a less percentage after the boiling and drying.

Gum wastes from the East, and particularly punjum wastes, are sometimes "faked up" with rice water, made into a sort of size, which adds weight to the silk in the raw, but boils out only too easily. Again, the Indian wastes are very dusty and sandy at times, which all means loss of yield.

Bleaching.—Some silks are very yellow in colour, and it is occasionally necessary to bleach them. Tussah is the most difficult silk to bleach, so that any method of bleaching this class of silk which can be applied successfully will also be found to suit other silks. But of course the strength of the liquor and the time occupied will vary according to the class of silk to be treated. The silk produced by the *Bombyx mori* is more easily bleached than tussah. The safest and most powerful bleaching agents are the peroxides of hydrogen and sodium, but being so costly they are only used for very special purposes. Sulphur bleaching is not now often practised, because the result is not permanent. The following is a good bleaching bath for 100 lb. of silk previously boiled off: 460 gallons of water, 30 lb. caustic soda, 20 lb. white curd soap, 20 gallons of hydrogen peroxide, and a little ammonia. The silk is steeped and boiled for a few hours, until the desired result is obtained.

A much cheaper method is the following: 460 gallons water, 20 gallons peroxide, and a little borax. The 100 lb. of silk is placed in this bath for from ten to twelve hours, and then turned over and allowed to remain for the same period, after which it is heated up from 120° to 160° F. for from two to four hours. The bath will last longer if a little soap is used.

Another useful chemical for bleaching is the one sold under name of "Blankit," but as this is or was a German product a substitute can be supplied by English chemical makers.

Picking silk.—After boiling, bleaching, and drying, the silk should be examined, and, as far as possible, all foreign matters, such as straw, China grass, hemp, hairs (from animals and human beings), hard-twisted ends, etc., picked out. This examination may be deferred until the after processes; but then the pickings are broken up into thousands more pieces, thus making the operation more difficult. The best plan appears to be to have the discharged waste, as it comes from the stove, looked over by females, who should take out all the large and easily seen deleterious objections. The waste may then have a second picking, which will be described in due course.

Foreign Matters.—The foreign matters to be looked for in the various wastes are—

Gum wastes—i.e. *thrown wastes.*—Hard-twisted ends, fine and coarse, usually called "silk twist," and made by the attendants in various reeling and winding processes, very often when making piecings; but the bulk of such faults are made by the cocoon reeler.

Steam, kikai, and curlies wastes.—Only a few straws and hairs are found—so few that they are not of much consequence.

Punjum waste.—Subject to rotten portions of waste and hemp.

Shanghai and Canton gum wastes.—Subject to silk twist, hairs, straws, and China grass.

Indian and szechuen wastes.—All sorts of rubbish—from paper to bits of cigarettes, from nails to pieces of hoop iron, straw and hemp to bits of rope, and hairs in abundance.

Some of the grades are full of balls of silk, and inside the ball is a piece of paper or some vegetable substance; then comes a layer or two of bad silk, then some good silk. The lower grades of waste contain from 5 to 15 per cent. of such objectionable matter, and therefore these wastes are shunned by most spinners, as it is impossible by any known system of picking to rid the waste of these faults, and in consequence the yarn resulting is only a second-rate article, and can only be used for very poor goods where imperfections are either not seen or do not matter. The hairs in the waste are from the animals like goats and sheep, and also combings from the heads of the peasants. It will be remembered that a large weight of silk is reeled in cottages by peasantry, and they often keep domestic animals in the same abode; therefore the hairs from them get mixed with the waste thrown on the floor during the reeling process, and all are mixed and sold together as silk. The deleterious matters in silk waste are chiefly vegetable and animal, and since competition has become keener, many attempts have been made to destroy them by chemical means.

Carbonisation.—In worsted spinning the purging of vegetable matters from the wool by means of so-called carbonisation is an accomplished fact, and it is a little surprising that this process has not come into general use in the silk spinning industry. Probably the reason is, that silk is a very costly article, and is very soon damaged by acids, and in such a way that nothing can remedy the defect. Sometimes the damage done to the silk waste in some of the processes has not been detected until the yarn has actually been spun and woven into cloth and then kept on the warehouseman's shelves for some time. When taken down, the goods have been found eaten into little holes, or the colour of the cloth has been affected, making it look "spotty," this being caused by the action of some acid which has not been thoroughly washed off the waste. Foreign schappe spinners have perfected a carbonisation process. Still it is quite possible to use this treatment for fully discharged silks. It is well-known to chemists that dilute sulphuric acid, strength 2 per cent. of acid at a temperature of from 50° to 55° C., will thoroughly carbonise ligneous cellulose, and for raw cotton the same percentage of acid and a heat of 76° C. will suffice. The effect of the acid and the subsequent drying of the waste at a high temperature are to convert the vegetable matter (cellulose) into friable hydro-cellulose, whilst the silk (animal fibre) is left intact. The grass, hemp, etc., first turns brown and then black, when a slight crushing by rollers reduces the matter to powder.

The acid requires thoroughly washing off the silk fibre or neutralising by alkaline treatment.

A method of carbonising by muriatic acid is as follows: The silk is taken from the drying stove and placed lightly and evenly on hurdles in an air-tight room, and exposed to the fumes of muriatic acid for from three to four hours. After this the temperature is raised to 300° F. for half an hour or so. The heating is stopped and fresh air let into the chamber. When it is cool enough, the silk is taken out and given a thorough washing to remove all trace of acid. It must then be re-dried, and on examination the

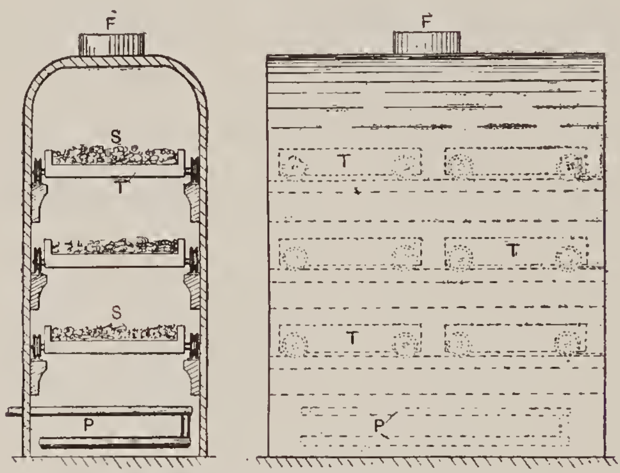


FIG. 31.—Carbonising chamber.

vegetable matters will be found brown and black and very brittle. A bath of sulphurous acid, a drying process, an alkaline bath, and a thorough washing afterwards will effect the same result.

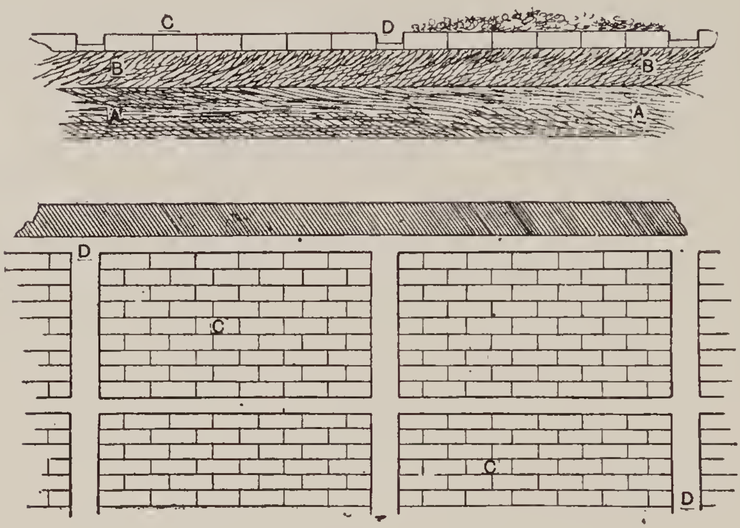
Fig. 31 illustrates a carbonising chamber in end view and side elevation. The treated silk S is placed on trays T, which can be easily handled and pushed into the chamber as they are filled. The chamber is heated by a tubular heater or steam-pipes P, and the hot air is drawn out by a fan at F when the silk has been in sufficiently long to effect a proper destruction of the vegetable matters.

It should be understood that this process is a *very delicate one*, and the least miscalculation or carelessness on the part of the work-people will absolutely spoil the silk, making it tender, rotten, and badly discoloured.

To ensure success undoubtedly a works' chemist ought to have charge of any carbonisation process.

Destruction of Hair.—Hair and silk both being animal fibre, it would appear that what will destroy the former must at least materially injure the latter, but chemical research during the last few years has shown that hair can be melted away without the chemicals used damaging silk fibre. Several patents have been taken out in this connection, but only very few firms have adopted the process.

Conditioning.—After all these treatments by heat and hot liquors the silk is in a dry condition, and if sent to the mill to be worked by machinery, the result will be bad work and very short, irregular fibres, so it must be allowed to absorb its natural moisture of 11 per cent. and over. Whilst silk will not work properly if dry and harsh, it will work if properly moistened with water, but it must not be *wet* in patches; hence, spraying with a hose-pipe and fine rose, or using the watering-can, is not satisfactory. It is absolutely essential that the silk be well and evenly dried in the stove or drying machine. If some portions are damp and others dry, the latter absorb moisture quickly, and the former get very wet, so that the silk is irregular in condition and works very badly in the after processes. It is also very detrimental to *force* silk into condition: it must have time to pick up moisture naturally, and the best-known means of allowing it to do so is to construct a conditioning floor. A cellar, well ventilated, but dark, is the best for the purpose. The floor is prepared (see Fig. 32A, which is a sectional elevation) by first putting down 12 in. of sand or ashes and broken stones to act as drainage A; over this is placed a layer of clay B, and then bricks C, with gutters D every 3 or 4 ft. apart. Fig. 32B shows the plan of this floor. When the floor is made, the bricks are thoroughly soaked with water, which gradually works down to the clay, and is there retained, always



FIGS. 32A and 32B.—Conditioning floor.

keeping the bricks moist. Excessive moisture finds its way through the clay and drains away through the rubble layer below. The gutters are kept half full of water,

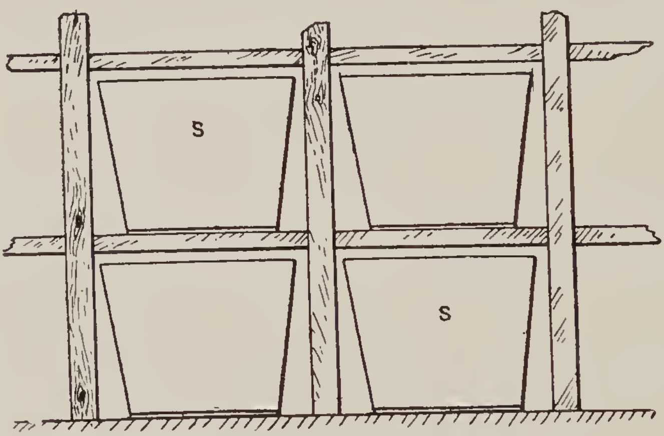


FIG. 33.—Conditioning shelves.

which is constantly evaporating, and keeps the atmosphere moist. The bricks must not be soaking wet, only damp, and then, when hot silk from the stove is spread thinly on them, the heat of the silk causes the moisture to ascend, and it is greedily absorbed from the bricks and the air by the dry silk, which soon begins to feel damp, soft, and pliable. A proper condition cannot be described in cold print; only experience and observation can tell when the process is complete. After the silk has lain sufficient time on the floor it is picked up and packed into large skips or placed into bins for some days or even weeks, to still further com-

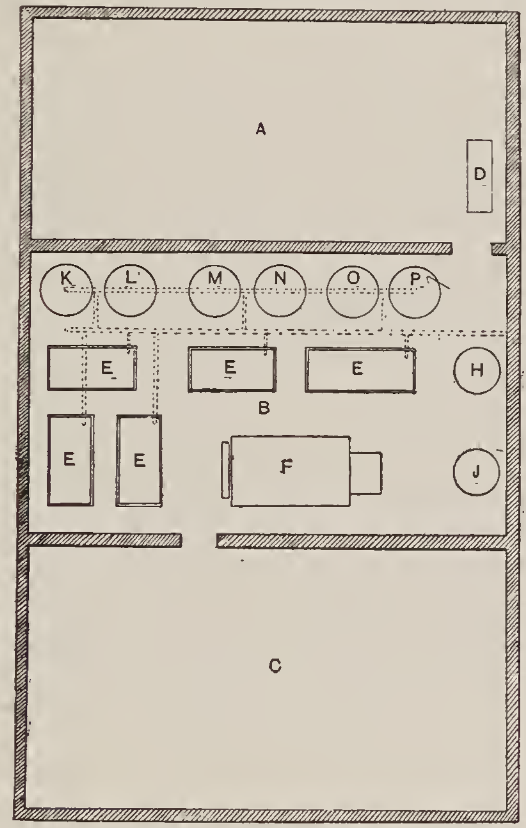


FIG. 34.—Plan of bale room, washing house, and conditioning floor.

plete the conditioning. These skips S are packed one above the other, as shown in Fig. 33, so that the contents can be turned over from time to time, and also to allow free access of air.

In Fig. 34 is shown a plan of a bale-receiving room A, boiling-house B, and conditioning-room C, with plant set out for convenient and economical working. The description is as follows: A is a bale-receiving and weighing-room, at the far end of which the waste-opening machine D is placed. At this point the silk is bagged preparatory for boiling or steeping. B is the steeping and boiling house; K, L, M, N, O, P are boiling tubs. E are steeping cisterns; or the same room can be occupied by various schapping machines. F is the drying machine, and if required the same machine can be used for carbonisation. H and J are hydro extractors. The dotted lines show drains. It should be remembered that over the tubs, K to P, can be placed the water-softening cistern, and, if it is arranged

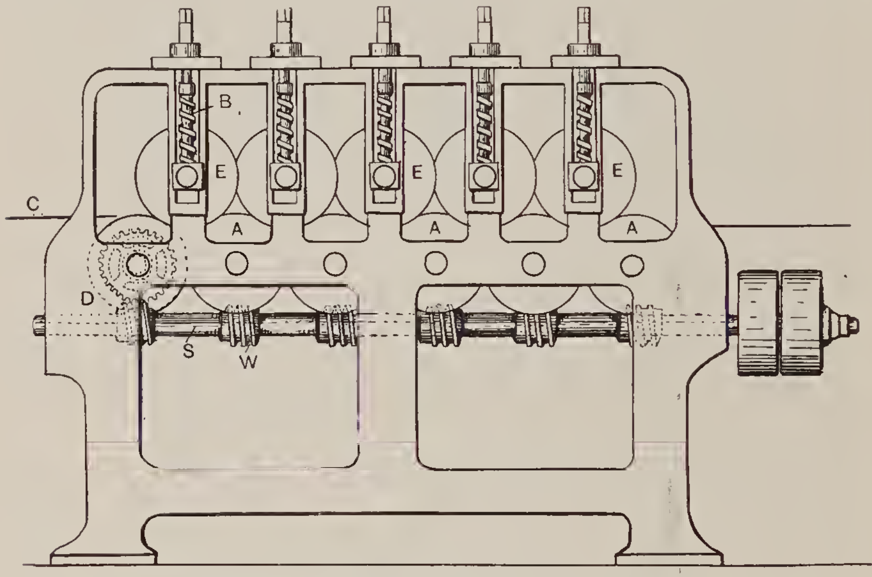


Fig. 35.—Supple machine, worm driven.

the same length as the length of space occupied by the tubs, a tap is connected directly from it and over each tub, to serve the same with the softened water necessary for perfect silk schapping or boiling. The drying machine is placed in the boil-house, because it can easily be attended to by some one or other of the workmen engaged in the silk boiling. C is the conditioning-room, into which the silk can be taken direct from the drying machine. The floor space is occupied by spreading on it the dry silk, and round the walls are placed the bins and skips, as shown in Fig. 33.

Suppleing.—The preceding description of conditioning may be termed the *natural* conditioning process, but in addition to this method there are ways of mechanical conditioning, and some silks work better if a little soapy.

For silks which incline to mat together during the schapping or boiling processes, such as knubs, steam wastes, etc., the supple machines shown in Figs. 35 and 36 are often employed. The shaft S—on which are fixed worms

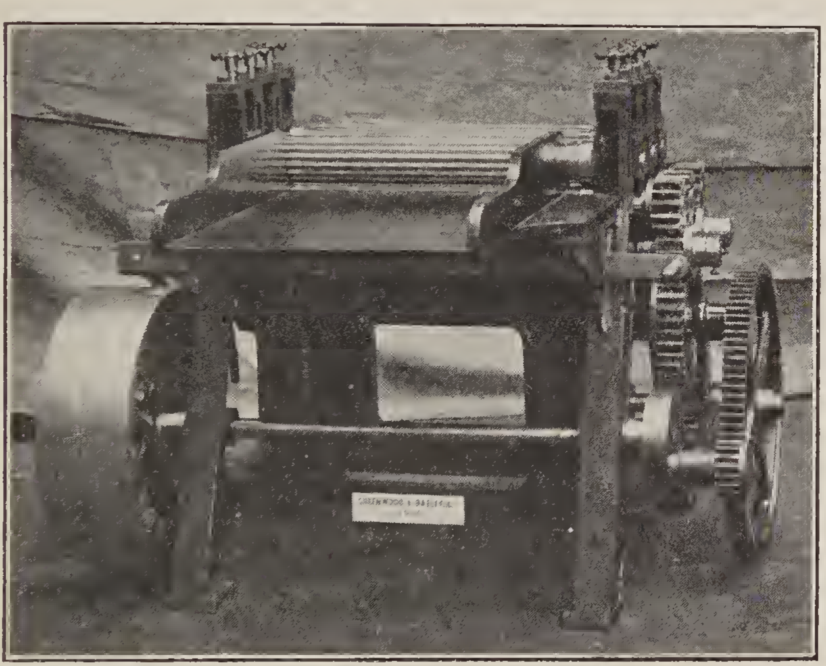


FIG. 36.—Supple machine, wheel driven.

W—revolves slowly, and drives the bottom series of fluted rollers, marked A, through the gearing shown by dotted lines at D. The silk is spread thinly on the latticed feeder at the point indicated by C, and is gradually worked through the machine between each set of fluted rollers A, E.

The chief purpose is to crush, bruise, and soften all hard, matted portions of silk, and such is well effected by means of these rollers and their springs B. The best results are obtained by having the silk moistened before feeding into the machine, and, if necessary, it may be put through several times. Should the silk have been in the carbonising chamber prior to treatment through this machine, the process will tend to pulverise all vegetable matter into powder, but the waste must be passed through the machine whilst in a dry state, *i.e.* straight from the carbonising chamber.

Many spinners before silk is packed into skeps or bins damp it, using a soapy solution or plain water in accordance with their idea of what condition the waste needs.

CHAPTER VII.

THE OPENING AND DRESSING OF WASTES (COMBING).

Cocoon beating.—Cocoons, whether schapped, boiled, or worked without either of these processes, are better for putting through what is termed a cocoon beater, one of which is shown in Figs. 37 and 38. This machine comprises a large disc A, revolved by means of pulleys E and K geared into the wheel C. On the disc are rods radiating from centre to circumference, and under these rods the

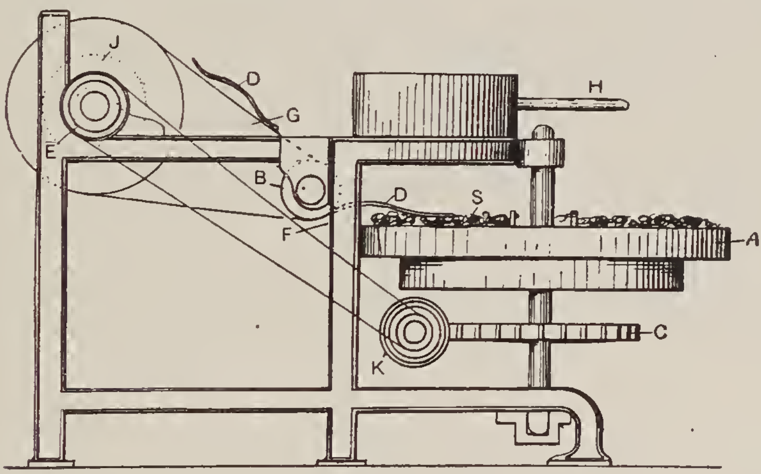


FIG. 37.—Cocoon beater.

silk is placed. The whips D, which are fastened on the belt G, thrash or beat the silk S, as shown in the illustration. The machine is under the control of the operator by means of the handle H, which is connected to main driving pulleys J, the driving pulleys being shown by dotted lines.

Some classes of cocoons are worked without boiling or schapping, but the fibres need loosening, and the silk must be beaten to become freed from the chrysalis and wormy matter. The cocoon beating or thrashing machine opens, softens, and renders flexible any kind of waste, and inflates the cocoons so that the work of the succeeding machines is rendered easier, and better results are attained in yield of silk and length of fibre.

The attendant is generally a female, who stands before the disc A, with the bulk of the material to be treated within her reach. She disengages the small rods which

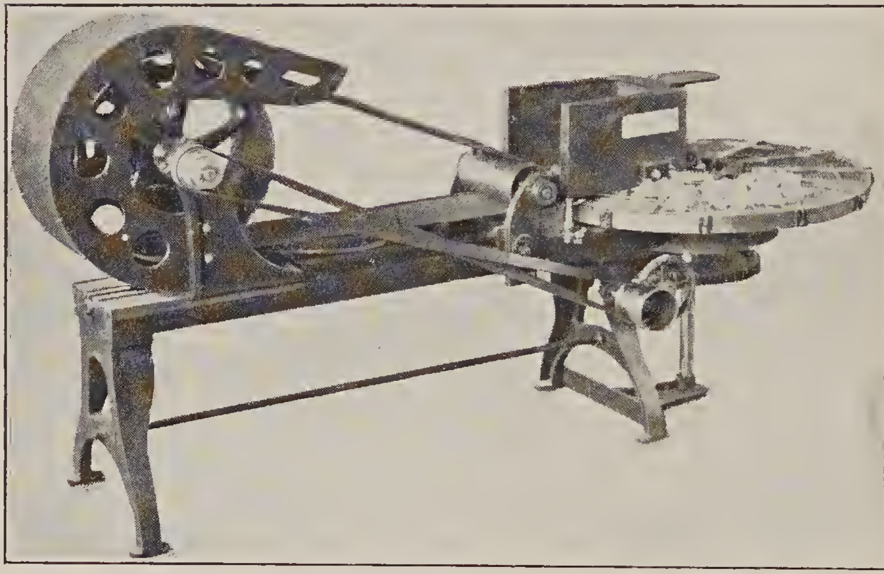


FIG. 38.—Cocoon beater.

radiate from the centre of the disc, and then spreads the silk S on that disc, and replaces the rods, which are held firmly on the material by means of balancing weights or springs. The disc revolves, so that the silk presents itself continually under the action of the whips D, and after a turn or two, without stopping the machine (which runs very slowly), the worker raises the rods and turns over the material, so that both sides have a proper beating. When sufficiently done, the treated silk is replaced by a new supply, and the operation proceeds as before.

The average speed of the machine is about 120 revolutions per minute of the pulleys E, which gives one turn per minute to the disc carrying the material. The length of time for properly beating the silk is from two to four minutes, according to the nature of the material and the degree of degumming. The action of the whip can be regulated by the height of a cushion placed at F, and this cushion also relieves the strain caused by the passage of the whip over the little pulley B. The production of such a machine is estimated at 250 lb. per day for cocoons, and 200 lb. for wastes (degummed or schapped).

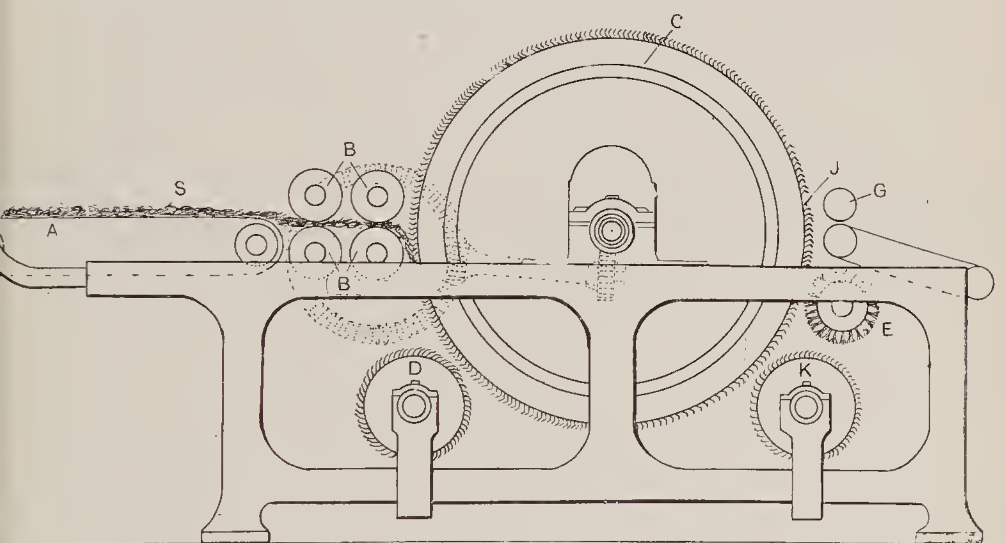


FIG. 39.—Opening machine for cocoons.

OPENING.—After this beating, the silk presents a more loose appearance, but is still in lumps of tangled fibre, to straighten which it is necessary to pass it through another machine known as a cocoon or waste opener, which places the individual fibres in a more parallel position. Fig. 39 shows such an opening or lapping machine for cocoons and waste. A is a latticed feeder on to which the silk S is placed. This feeder carries the silk to the rollers or porcupines B, which grip it firmly, and at the same time feed it very slowly to the large drum C. This drum, being covered with fine steel teeth, and revolving at a great speed, tends to draw the silk on to its teeth in straight and parallel fibres. D and K are smaller rollers covered with steel teeth, E is a brush, and G are stripping rollers.

Fig. 40 is a lapping machine for knubs and waste, and is essentially the same in most parts as the one just described. In place, however, of the feed or porcupine rollers being like those in Fig. 39, the silk is fed on to the large drum C by means of porcupine sheets A and B, while the brush E is altered as to position. Both machines are

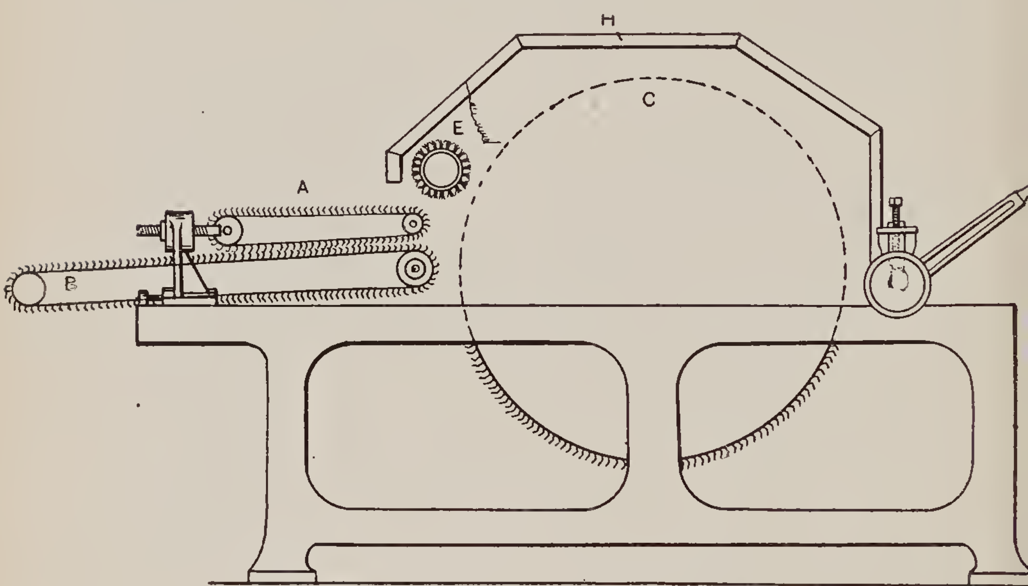


FIG. 40.—Lapping or opening machine for waste.

always well covered, as shown in Fig. 40, by a casing H, and if the silk is very dusty these casings are connected to a dust trunk, and the dust withdrawn by means of a fan. Both machines work in the same manner. A given weight of silk, which may or may not have been thrashed, is entrusted to the workman, who spreads it on a given space on the feeder, which then carries it slowly forward towards the big drum. This drum is covered with steel teeth set in vulcanised rubber (Fig. 41), so that they are slightly pliable, but still sufficiently firm for the work they have to do. The drum revolves at a high speed, and as the silk projects through the feeding rollers or porcupine sheets, it is caught and pulled forward by the quickly passing teeth of the large drum C, which so opens out the tangles until a portion is pulled through the feeding rollers and spread evenly and thinly around the drum. The few portions of silk, which are either lumpy or so short that they slip too quickly through the retaining rollers (and so on to the teeth in matted pieces), are caught by the small rollers D or K (also covered with teeth) and opened out by them. As silk is very fluffy, light, and liable to remain on the points of the pins, brushes E are placed at different points, which revolve against the big drum, and so press the silk down into the teeth, leaving the points of the teeth free

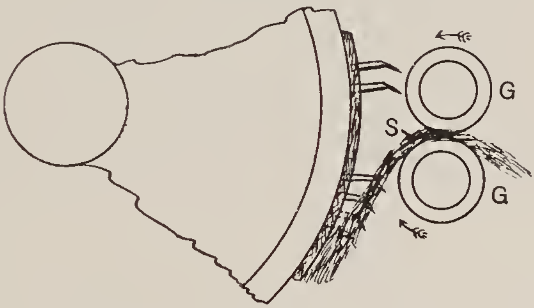


FIG. 41.—Opening machine teeth.

to do their work at each revolution of the large drum. The hard small bits of silk, dirt, and chrysalis fall to the bottom of the machine, and can easily be removed afterwards. When the necessary weight of silk has run on to the large drum, the workman stops the machine, opens the cover from behind, and cuts the silk (now called a lap) with a knife in the part of the drum not covered with the pins J, and follows, with the knife, the axle of the drum. He then disengages the upper part of the lap in sufficient quantity for placing between the stripping rollers G, to which he gives a rotary motion which withdraws the lap from the big drum. The stripping rollers G, having the silk S between them, are revolved in the direction shown by arrows in Fig. 41, and the lap is so strong that it pulls round the big drum, thus freeing itself from the teeth.

Filling.—The lap produced by the opener is passed forward to a filling engine, which at first sight seems to be like the opener, but the feed rollers are stronger, or are replaced by strong porcupine sheets, and exercise a strong grip on the silk. The difference between the opener and filler is in the setting of the teeth or combs, which, instead of being all around the drum, as in the opener, are placed only in rows, each row from 4 to 9 in. apart, the teeth being about half an inch from one another. They are set on the face of the drum, each row of teeth following the same line as the axle. Silk which may not have

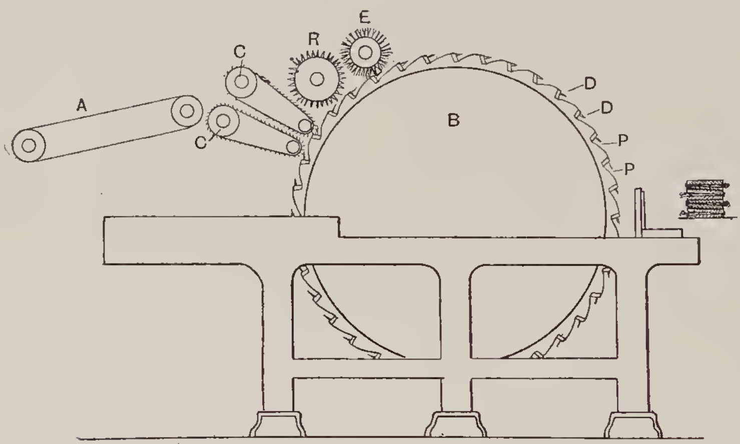


Fig. 42.—Filling engine.

passed through the opener *must* be put through this process. Figs. 42 and 43 show the machine, and the following is a description of its action :—

A lap of silk from the opener, or a weighed portion of unlapped silk, is put on the feeder A in a given space, and travels slowly into the porcupines C. The big drum B revolves quickly, and the rows of combs D pull a small portion of the silk from the porcupine rollers C, until by continual revolving the whole drum is covered uniformly with silk. When the portion placed on the feeder is exhausted, the machine is stopped and the silk cut with a knife or scissors at a point P between each set of teeth, thus making a fringe of silk hooked on to the pins. The porcupine roller R straightens any lumps which adhere to the comb, and picks up short portions of silk. The

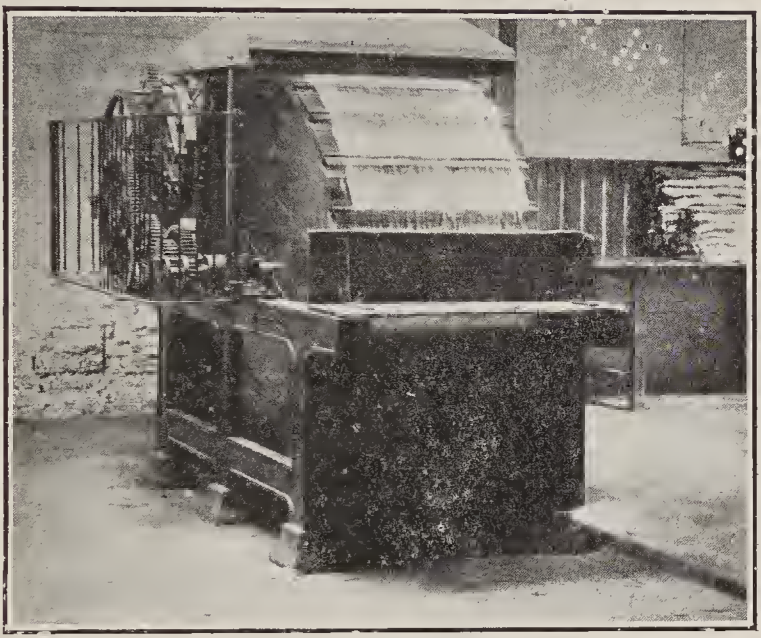


FIG. 43.—Filling engine.

brush E transfers such silk from the porcupine roller back again to the tooth of the large drum.

When the attendant has so cut all the silk on the drum

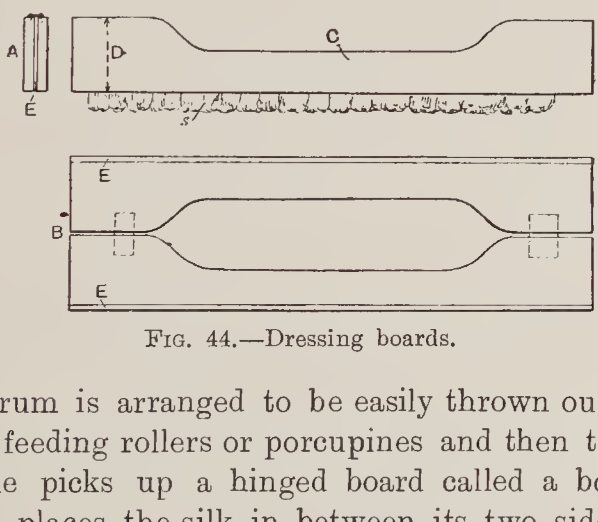


FIG. 44.—Dressing boards.

(which drum is arranged to be easily thrown out of gear with the feeding rollers or porcupines and then turned by hand), he picks up a hinged board called a bookboard (Fig. 44), places the silk in between its two sides, closes them tightly together, pulls gently towards himself whilst standing in front of the large drum, and so strips the silk off the pins. Care is taken to keep the bookboards firmly pressed together so as to retain all the silk, shown at S (Fig. 44). Another method of stripping the pins is by means of a small wood rod about 28 in. long and $\frac{1}{4}$ in. diameter. The silk being cut into the fringe form on the filling engine, the wood rod, first dipped in a soapy solution to make the silk adhere, is placed on the end of the silk fibres and rolled towards the workman, thus wrapping round itself the silk until all the length of fibre is on the stick or rod. Then a good pull towards the attendant clears the pins. Fig. 45 shows (end view) at A the board stripping, and at B the stick stripping.

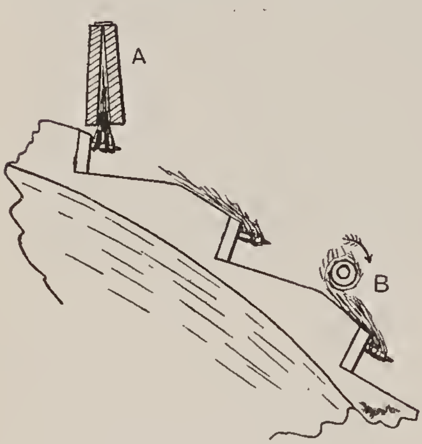


Fig. 45.—Stripping.

It will be noticed that the bookboards are hollowed in the middle, as shown at C in Fig. 44, which hollowing is to enable the workman to handle them easily. They are usually about 28 in. long and 5 to 7 in. deep at D and about $\frac{1}{2}$ in. thick; that is, when compressed or closed into the form of a book, the two sides are each $\frac{1}{2}$ in. thick. Each inside edge is covered with a strip of roller cloth E, about $\frac{1}{2}$ to $\frac{3}{4}$ in. wide, to cause the silk to be more firmly held between the two sides.

It is perhaps well to point out that all the operations described up to this point have been, in the first place, to rid the silk of gum or to soften the fibres, so that they are pliable and fairly well separated from each other. In the second place, the tangled lumps or masses of crossed fibres have been beaten, suppled, and opened. The opening machinery treats the silk very gently, and the setting of the porcupines or feed rollers in relation to the working drum or cylinder is regulated by the quality of the silk (by quality is meant the kind of fibre or waste). For instance, a cocoon waste would take far more opening than a European gum waste, so the teeth or combs on the cylinder of the openers have to be fine or coarse, set pliable or otherwise, in accordance with the length and strength of the fibre to be worked. The shorter and more tender the silk, the more gentle must be the treatment it has on these machines, as the object is to obtain as great a proportion of long fibre as possible. The lap of silk from the opener is weighed before being placed on the feeding sheet of the filling engine, because it is necessary that each strip of silk from the filling engine comb should be nearly the same weight.

The function of the filling engine is to still further open out the silk, and to lay the fibres more parallel to each other. Then the setting of the teeth or combs in rows, a certain distance apart, is for the purpose of commencing to equalise the lengths of the fibre. The way silk waste is produced means that some fibres are cut and broken into lengths, varying from $\frac{1}{2}$ in. to 30 or 40 in., and it is obvious that these lengths must be separated to enable a yarn to be spun. The longest fibres are useless, being too long, so they must be cut; the short fibres must also be got out, or they spoil a yarn.

The distance from point to point of the teeth P in the filling engine (Fig. 42) gives the length of the longest fibres deemed best to work, and that distance is regulated by the nature of the silk waste. A waste which will work long—like Swiss, China, and most European gum wastes—is put on an engine with teeth set in rows from 9 to 12 in. apart, whilst a waste matted together like steam waste, and at the same time soft and fine in fibre, needs the rows only to be 6 to 7 in. apart.

The speed of the large cylinder of the openers and fillers, can be regulated in relation to the speed of delivery of the feed rollers or porcupines, and it is very essential to watch this point—to see, on the one hand, that the silk does not go on in lumps; or, on the other hand, that it is not pulled to pieces. The weight of the silk fed to the machine in a certain time, and the thickness in which it is placed on the feeding sheet, all depend on the nature of the silk and its previous treatment. It should, however, never be forgotten that the feed must be uniform. Each revolution of the large cylinder should draw on to each row of teeth an equally sized fine film of fibre, and the brush E. (Fig. 42) should be placed so that it will brush that film down to the root of the tooth, keeping the point free to work, and at the same time helping to keep straight the fibre, and to make a hard, solid strip, each strip being of the same thickness and weight.

Dressing.—Attention and care in opening and filling is amply rewarded by the result of the next process—silk dressing—which is the most important of any single process in silk spinning. It is equivalent in silk to wool combing in the worsted trade; but whilst both industries began their dressing or combing in much the same way, they are now widely different in all respects. Whilst wool combing is comparatively a cheap process, silk dressing is an expensive operation; in fact, it is the most costly of any single process throughout a silk waste spinning establishment. Of all textile fibres silk is the most valuable, by reason of its length and strength, coupled with its fine fibre and lustre. The shorter the fibres composing a silk yarn, the less lustre will that yarn show; whilst the longer the fibres, the more lustrous the yarns.

The object of silk dressing is, in the first place, to sort out the different lengths of fibre; and, secondly, to clear such fibres of nibs and noils. The longer fibres are used for the best yarns and the shorter for inferior kinds. The old-time system of dressing was, of course, a hand process. Each worker had heckles or combs, like the one shown in

Fig. 46, supplied to him, through the teeth of which a portion of silk was drawn. The short silk and noils and nibs adhered to the teeth, until by a continued repetition of the process, the silk held by the worker was straight and the fibre parallel and free from short silk and nibs. Then the portion dressed was held by the workman, and the portion previously held in his hand put through the combing process. When both ends were properly combed, that portion of silk was placed on one side for spinning, and the short fibres and noils were considered waste.

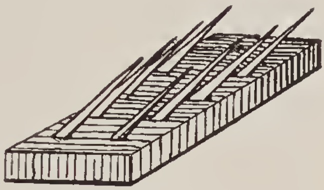


FIG. 46.—Heckle.

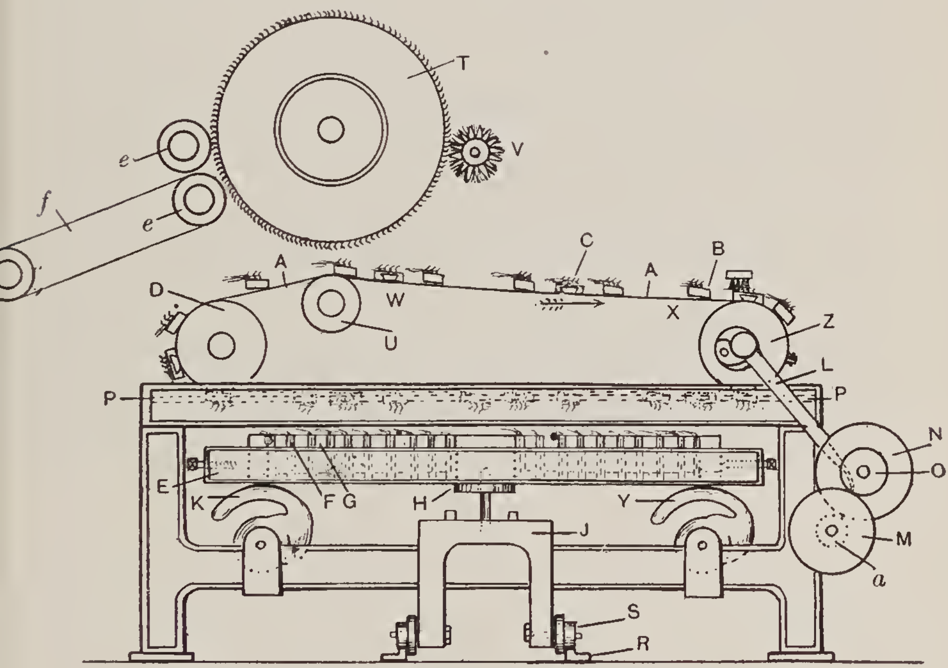


FIG. 47.—Flat dressing frame (side section).

The reversing of the ends tested the skill of the operator, as the teeth of the comb had to strike the silk at a point (the combed half being held by the workman) so as to ensure the middle of the silk being properly combed out; otherwise the centre of the lengths of fibre would be rough and woolly and have a large amount of short fibre left in them, making it impossible to have a level yarn.

This crude method is, of course, long since dead, and mechanical means are now employed to give the same effect. There are three machines in everyday use, and known respectively as the flat dressing frame, the circular frame, and the continuous flat dressing frame.

Flat dressing.—The flat dressing frame is illustrated in Fig. 47, in side elevation, and Fig. 48, while Fig. 49 gives

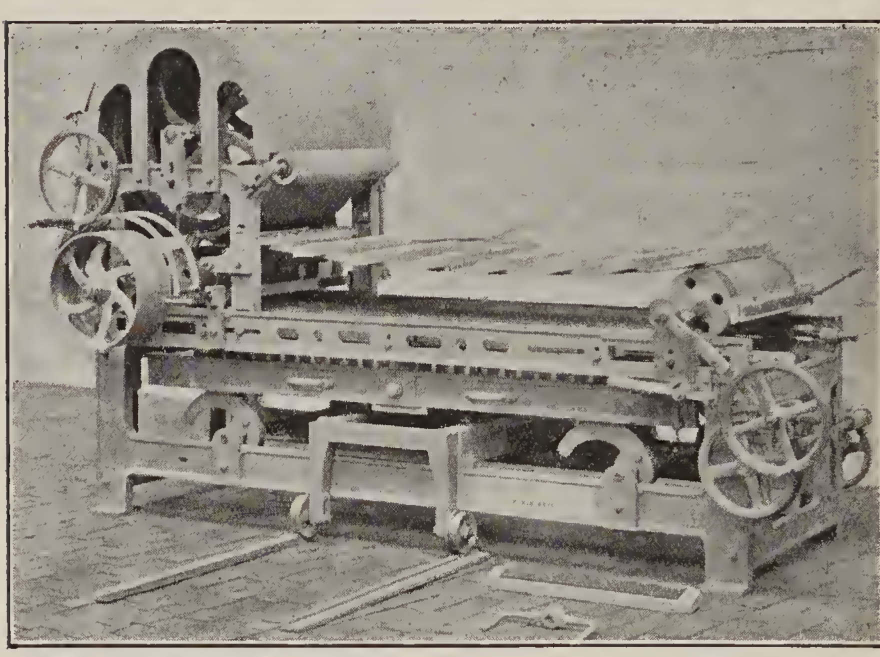


FIG. 48.—Flat dressing frame with stripping drum.

the end elevation. Fig. 50 shows inframe full of silk. It comprises a single endless sheet or web A, carrying a series of combs B and cards C, travelling horizontally in the direction marked by the arrow around a pair of rollers D and Z. There is also a box E, called an "inframe," Figs. 47 and 50, in which the bookboards of filled silk are placed, each bookboard F being separated from the next by a single board G, somewhat thicker, and called a slider. The inframe is swivelled on the centre H, so that it can be easily turned right round, and it is supported on a movable carriage J, to enable the dresser to push it under the moving combs or to pull it from under them for taking out the combed silk, etc. In addition to the support at H, the cams K and Y support each end of the inframe, and are also used to vertically lower or raise the frame of silk into contact with the working combs and cards. This is effected very gradually and automatically by means of the ratchet L and ratchet wheel M, every revolution of the roller Z thus moving the ratchet wheel M one tooth forward, and by

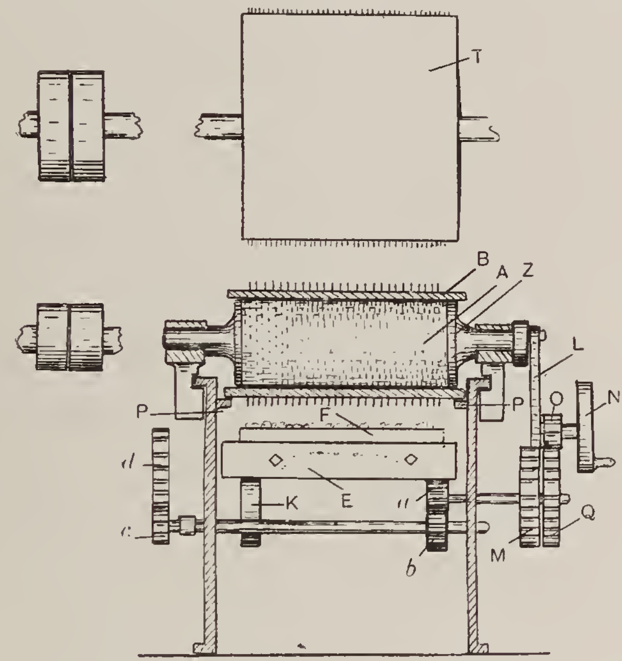


FIG. 49.—Flat dressing frame (end view).

means of the various wheels, shafts, etc., shown in the end and side elevation, Figs. 47, 49 and 51, the inframe is raised to any desired height. If the raising motion is not performed quickly enough by these means, the dresser can throw the ratchet out of gear, and, by means of the wheels *a*, *b*, *c*, *d* and N, O, Q, turn the inframe up or down at any desired speed.

The combs B and the cards C are shown in section in Fig. 47, and it may be here said that the combs are fixtures, being bolted securely on to the webbing, whilst the cards

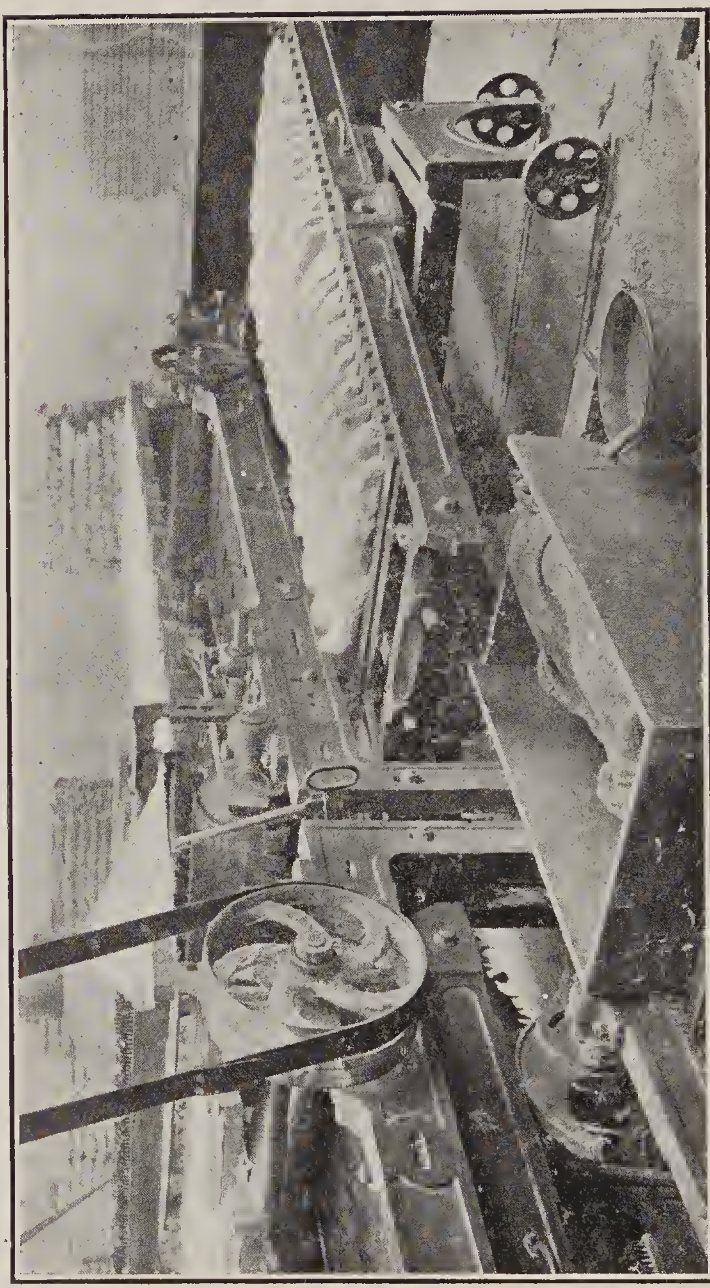


FIG. 50.—Dressing frame.

are movable, being in use only at intervals during the dressing operation. They are taken on and off whilst the machine is in motion, and therefore the V-shaped card back A (Fig. 52) is bolted to the webbing, so that the card itself will easily slide on and off, but by reason of the V-shaped holder cannot fall off when travelling point down-

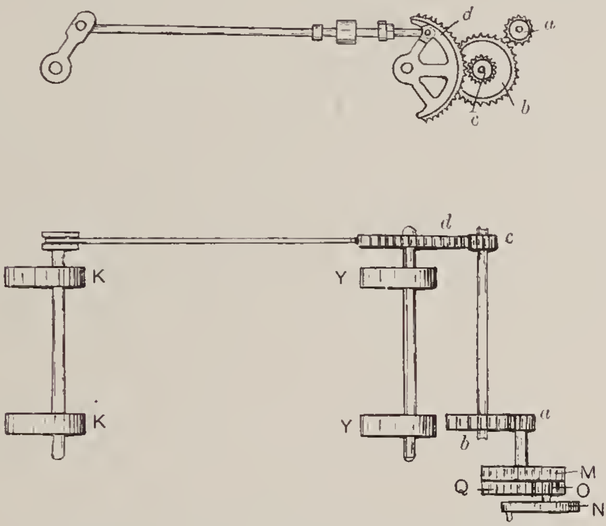


FIG. 51.—Flat dressing frame lifting gear.

wards and working on the silk. Both cards and combs are slightly tilted from back to front to prevent the silk

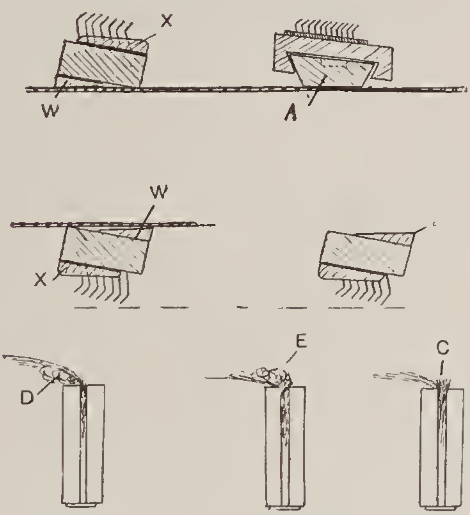


FIG. 52.—Combs, cards, and dressed silk.

choking the front teeth. The comb wire is set in vulcanised rubber, and is made pliable or otherwise, set coarse or fine, long or short, at the whim of the silk dressing foreman or mill manager. Coarse silks need a strong wire and fine silks a fine wire, while the style of filling and boiling has a great deal to do with the wire necessary to be used for the best dressing.

The webbing is made of hemp, and as this will shrink or otherwise in accordance with the state of the weather, the rollers D and Z are fixed in movable brackets, so enabling the webbing to be slackened or tightened as required. To ensure good dressing, the web should be kept fairly tight. It must also be perfectly level for its entire length from centre to centre of the rollers; and to prevent any

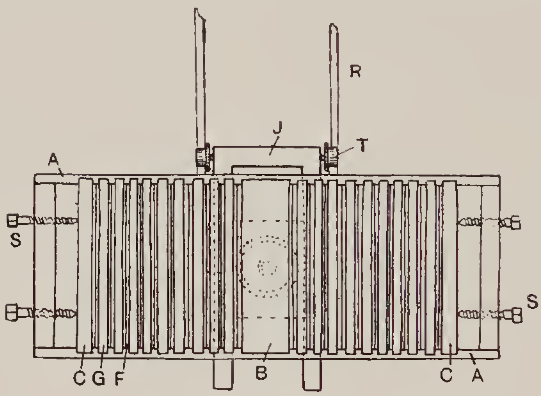


Fig. 53.—Inframe.

danger of "bagging" in the middle of the web, the working combs project at each end on to shelving P (Figs. 47 and 49), which is arranged from end to end on each side of the dressing frame. These can be raised or lowered to accommodate different thicknesses of comb backs, and to allow for wear and tear. The combs and cards are kept flat and rigid and at a proper angle by means of the wedge W and the shoe X (Fig. 52).

The inframe is shown in plan in Fig. 53. A is a cast-iron frame, a partial end section of which is shown in Fig. 54. It is divided in the middle by a strong metal partition B, called the middle bar, which is capped with wood. At each end of the frame is a pair of screws S, to enable the bookboards full of silk to be compressed, for these latter have to be compressed sufficiently tight to prevent the silk being drawn out by the action of the working combs. Fig. 53 shows the position of the sliders at S, and also the method of fixing on the cast-iron frame A.

The first operation in silk dressing is filling the inframe with silk, and for this the strips of silk are taken from the filling engine in bookboards, as shown at A in Fig. 55 (half a bookboard). These are placed in the inframe, commencing against the middle bar, and then a slider is pushed close to the bookboard; the second bookboard is placed against the first slider, and so the frame is gradually filled. When full, the screws S are operated, each screw for a short space. Then the boards of silk are all tapped down, until their tops are level with the surface of the

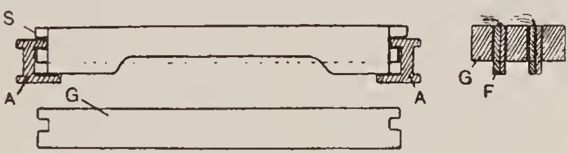


Fig. 54.—Bookboards and sliders.

sliders, as shown at B, Fig. 54, and the screws again operated until the silk is held fast between each half of the bookboard.

The frame, full of silk, supported on its carriage J, is traversed on the rails R (Figs. 53 and 57) by their wheels T under the combs, which are then set in motion. The operator, by means of the handwheel N, raises the frame until the silk touches the teeth of the combs, and then he puts in gear the ratchet wheel and allows it to raise the silk deeper and deeper into the moving combs. When the teeth have combed about half-way through the depth of silk, as shown at D in Fig. 52, the inframe is let down, pulled from under the web, turned opposite end about, and the silk which lay in the direction of the points of the combs is reversed so that the rough uncombed portion is uppermost (E, Fig. 52). The combing operation is then repeated until the teeth have gone through the silk and both sides of the tuft are combed through.

The inframe is then again let down, the carriage and frame are pulled from under the working combs, the screws loosened, and the boards of silk freed. The dresser takes out a bookboard of silk and places it on a table like that shown in Fig. 56 in the position A, thus allowing the dressed portion of silk to project over a cast-iron guage B (C is plan of same), which measures $\frac{1}{4}$ to $\frac{3}{4}$ in. square by

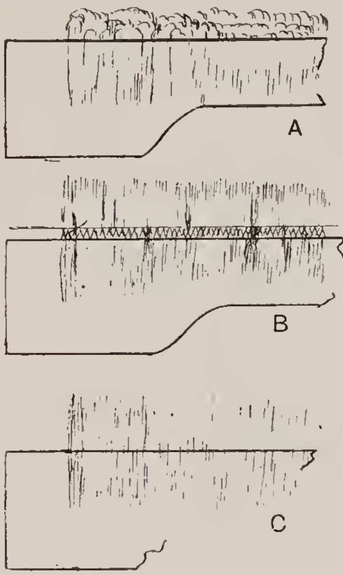


Fig. 55.—Dressed and not dressed strips of silk.

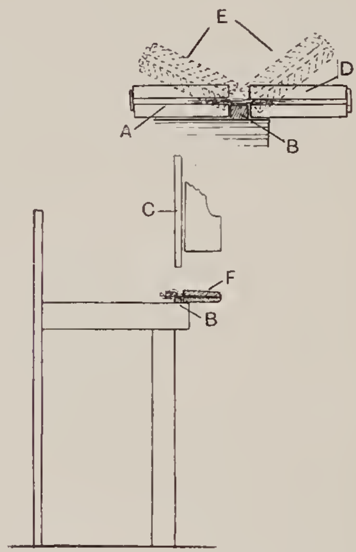


Fig. 56.—Turning-in board.

30 to 36 in. long. The dressed portion is then gripped by another pair of bookboards D, so that the undressed ends project for combing, as shown at F. All the silk is "turned" in this method, then replaced in the inframe, and the preceding processes of combing gone through. When completed, and whilst the inframe is almost at its highest point in relation to the working combs, the fine cards C are placed in their respective positions, and the silk subjected to their action for several minutes for the purpose of removing nibs from the fibre. The combs

straighten and open the fibre, whilst the cards smooth it and remove rough, hard places.

When the silk is sufficiently cleared the inframe is let down, the silk again "turned" in the boards, replaced in the frame, and the ends, which at first were combed only, are then subjected to the finishing touch of cards and combs. If properly "turned," the silk presents the appearance shown at C in Fig. 55, all the fibres being straight and parallel from end to end, no short fibres being left in the centre of the tufts of silk. If not turned properly, nor properly dressed, short crossed silk is left as shown at Fig. 55, under line D. Short silk may also be caused by running the combs and cards too hard on the silk, and then the ends are broken and cut as shown at C in Fig. 52. In turning in the boards, the dresser should never be allowed to raise the bookboards above the gauge B higher than shown by the dotted lines E in Fig. 56, or he will most probably *turn short*, and bad dressing will result. When the dresser considers the silk dressed, he empties it from the bookboards and places it straight in a box or tin. The dressed fibres resulting from the strips taken from the filling engine are called "first drafts," meaning the "longest fibres."

It will be understood that the tufts of silk which gather on the combs, as shown at Fig. 47, are usually stripped from the combs by the silk dresser whilst the combs are at work and during their passage from W to X, and they present practically the same appearance as the "strips" from the filling engine. Bookboards are used exactly as depicted at A in Fig. 55. These strips are combed and dressed in the manner described for first drafts, and the resulting dressed silk is called a "second draft"—*i.e.* the second length of fibre. The silk accumulating on the combs in this operation forms the third draft, and all the respective processes are gone through in the same manner as for first drafts, except that as the silk gets shorter in fibre for each operation, the gauge in turning will be less.

Six or seven drafts of silk are thus obtained from the strips of silk originally brought from the filling engine, and when the fibres are too short to make it worth while dressing any longer, the strips on the working combs are taken off by bookboards and then put on one side and sold as noils.

Whilst board stripping is the usual method of clearing the working combs, a large drum can be used as shown at T in the upper portion of Figs. 47 and 49. By this means the combs are always kept clean. The web is supported by the roller U, Fig. 47. The large drum is covered with fine wire filleting, and is set so that the points of the wire just lift the tufts of silk out of the working combs as they pass over the top of the roller U. The silk is pressed into the wires by a brush V, and when the drum has sufficient silk on its wires, forming a solid lap, it is stripped off by means of the rollers *e* and the leathers *f*. The stripping drum is driven by means of pulleys fixed on the end of the shaft of cylinder, as shown in Fig. 49.

In the case where the large drum is used for stripping the working combs the lap from the former has to be refilled for dressing on a small filling engine, which will be described later. As each successive draft of silk gets shorter in length and finer in fibre, it is usual to adopt different combs for the shorter fibres than for the long drafts, and consequently silk dressing machines are worked on the three-frame system illustrated by the sketch Fig. 57. In this plan 1, 2, and 3 are dressing frames, known respectively as first, second, and third frames. A is the inframe; T is the tabling, always fixed at one end of the dressing frame and used by the dresser as a storage place for his empty and full boards, and also to *turn* the silk upon; R are the rails on which the inframe traverses to and fro, under and out, of the dressing frame. The distance from 2 to 3 on the one hand and 1 to 3 on the other is sufficient to allow the inframe to be pulled from under the combs and turned completely round on its centre pin, in order that each side of the tufts of silk may be presented to the action of the working combs, etc.—*i.e.* the end marked E would be under B in the dressing frame at the first running-up of the silk into the combs, and the end F at the second rising of the silk.

The three frames are in charge of an operative called "first framer," who has under him two others, "second and third framers," the last named being a youth. As the names imply, the operatives attend to the respective machines 1, 2, and 3. The first framer fills the boards from the filling engine, places them in his inframe, and

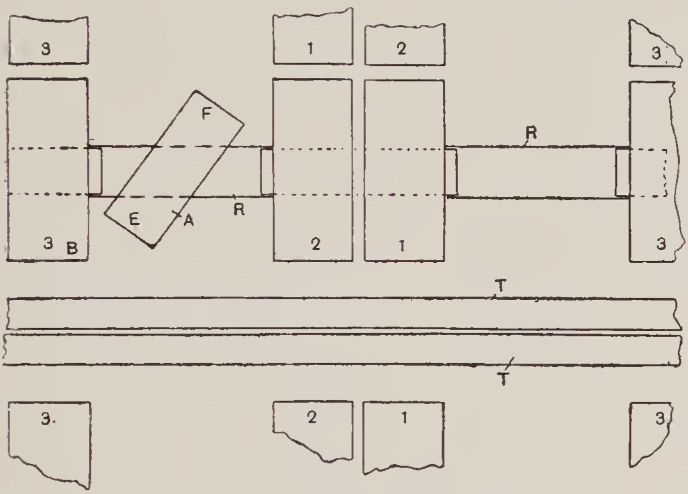


FIG. 57.—Plan of set of flat frames.

dresses the silk they hold. He strips the combs frequently, and hands the strippings to the second framer, who dresses the second and third drafts, and who in turn hands over his strippings from the third draft to the third or short framer, who dresses the fourth, fifth, and sixth drafts. When dressing the last draft he strips the combs clean at intervals, these strippings being known in the trade as noils. A "fill of silk"—*i.e.* the weight spread on the filling-engine feeder—will weigh about $3\frac{3}{4}$ lb. for an engine which has twenty rows of teeth, making twenty strips of silk. The first frame will have ten boards in each division of its inframe, thus accommodating the twenty strips from the filling engine. The second frame will have twelve boards in each division of its inframe, and the third frame fifteen boards, this increase being necessary; for although the later drafts are shorter in length, they are more bulky, being very light and fluffy, and consequently the strips of silk must be kept light in weight so as to enable the working combs to dress, and not cut the silk to pieces. Each inframe is of the same length, and to hold the number of boards the sliders are narrower in the second than in the first frame, and in the third than in the second in proportion to the number of boards in each frame.

A week's work for these three frames and three attendants on a usual English quality would be approximately as follows :—

First frame receives from filling engine 148 lb.; yields first drafts 40 lb.

Second frame receives strippings from first frame 108 lb.; yields second drafts 27 lb., and third drafts 18 lb.

Third frame receives from second frame 63 lb., and yields fourth drafts 9 lb., fifth drafts 7 lb., and sixth drafts 5 lb., leaving 42 lb. noils.

The dressers are generally paid on the yield of drafts per week, but the costliness of the operation is much increased on account of there being but a comparatively small percentage of dressed silk from the original weight of silk waste put into the machines. The quality named above produces in percentage, approximately, as follows :—

	Fed into Machine.			
From filling,	148 lb.	yields	27 per cent. of	1st drafts and 73 per cent. strippings.
1st strips of	108 lb.	yields	25 per cent. of	2nd drafts.
2nd ,,	81 lb.	,,	22 ,,	3rd drafts.
3rd ,,	63 lb.	,,	16 ,,	4th drafts.
4th ,,	54 lb.	,,	12 ,,	5th and 6th drafts together.

Thus, by assuming that the first framer gets 30s. per week, the second and third framers 22s. and 15s. per week respectively, the cost per lb. of dressing—accepting the above yields and percentages—will be 9d. per lb. on No. 1 machine, 6d. per lb. on No. 2, and nearly 9d. per lb. on No. 3, or about[1] 8d. per lb. on all drafts received from the machine. As silks vary very much in yield, the cost per lb. varies accordingly. A high-class European gum waste will yield from discharged waste about 86 per cent. of all drafts and 14 per cent. of noils, whilst a low Eastern waste will yield 60 per cent. of all drafts and 40 per cent. noils.

The time occupied in completely dressing a frame full of first drafts is about 1¾ hour, second and third drafts about 1 hour, and fourth to sixth drafts about 50 minutes, including all turning of silk boards. The speed of the working combs is about 60 per minute passing any fixed point. This slow speed is necessary to ensure the silk being combed gently so as to keep the fibre as long as possible. If run too quickly the combs break the fibres, the friction of the steel teeth heating the silk and causing it to break off short, and leading to a larger yield of noils and less drafts. Then, again, if the combs were running quickly the workman would not be able to strip them without stopping the machine, and this would interfere with production and consequently increase the cost of dressing.

Re-dressing.—If a yarn is required extra strong and very level, many spinners resort to re-dressing. The wastes used are European gum wastes, which are filled and dressed in the gum state—*i.e.* not discharged. This gives a long fibre in the first draft. The dressed silk is made into small "paps" or bunches by the dresser and then taken to boil. When boiled it is conditioned in the usual way. Each pap is straightened out, placed in the dressing frame, and dressed exactly as an ordinary filled silk. In this way the silk is a better average length, and seeing that

[1] These costs were pre-war. Reduction in hours of labour and increase in wages has made cost of dressing in England advance by three times in year 1920.

it is turned over the gauge so much oftener than ordinary dressed silk, it is more free from short fibres. Naturally this extra work makes the dressed silk more costly, and so re-dressing is only done for very special purposes.

Circular dressing frame.—It is natural that such a costly process as flat-frame dressing has led to many attempts to find a cheaper method. Our competitors abroad use the circular dressing frame because of its capability of turning out a large weight of silk at a cheap rate. The English dresser does not use this machine, for whilst admitting its productiveness, it damages the silk and gives a lower yield per cent. of drafts, so much so that the saving in wages is more than counterbalanced by the loss of 3 or 4 per cent. of drafts. Naturally the question arises, Why this difference of opinion at home and abroad? The answer appears to be that the foreigner schappes his silk in the preparing process, and by leaving a small percentage of natural grease on the fibre protects it somewhat from the severe action of the working combs of the circular dressing frame, whereas when the silk is fully discharged (as is the English custom) it is very tender, and the great speed at which the circular frame combs work tears the silk to pieces, producing more noils and giving a worse yield of dressed silk or drafts.

Fig. 58 illustrates the circular frame in side elevation. A is a large drum divided into five sections, each furnished with boards or sliders B, of a thickness proportionate to the length of silk to be dressed. These sliders are grooved on their face, and are placed with the grooves in juxtaposition, as shown at C. Into the grooves fit small rods of wood which are longer than the sliders, so that each end of the rod projects to allow of their manipulation. As the larger drum revolves in the direction of the arrow, the sliders are compressed and opened by means of springs S and levers L. Y and Z are the cylinders or working combs; Y is designed to open out the silk and to comb almost through the film, while Z combs the other side, and being of finer wire also clears off the nibs in the same manner as the fine cards of the flat frame. The working combs are stripped by means of the stripping rollers E. Each comb can be thrown out of gear whilst the large drum is revolving, and so stopped and stripped of its silk, which has been pressed down hard into the roots of the teeth by the brushes F.

The machine needs two operatives, the dresser and his assistant. The dresser standing on the platform P, places

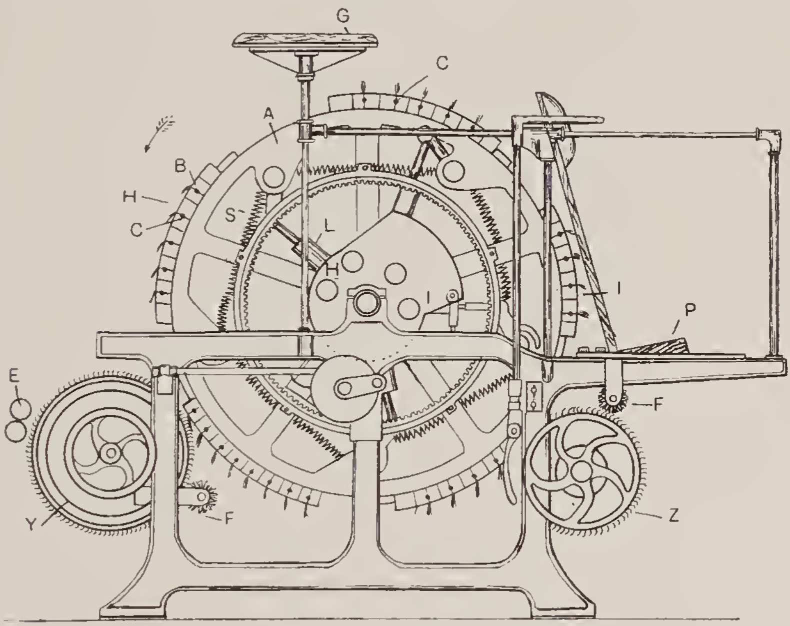


FIG. 58.—Circular dressing frame.

the rods, with the films of silk taken from the filling engine, on the shelf G. The machine is set in motion, the large drum is rotated very slowly, the section opposite the workman is open, and he places the rods of silk—one in each groove C—as the grooves pass before him; but on the first turn of the machine he only fills half the section. As the section passes opposite the point H, the sliders are automatically locked together and the silk nipped firmly so that the action of the combing cylinder Y, which revolves quickly, will not pull out the silk from the sliders

As the drum moves round to the point I, the sliders are unlocked, enabling the workman to turn the silk, the end dressed being wrapped round a rod, the undressed end then projecting for dressing. The workman also fills up the other half of the section with silk, so that on the drum's second turn one half of each section holds silk which is completely dressed—that is, both ends have been subjected to the combs, while the other half has silk with one end only dressed. The dressed silk is removed by the workman, and the section re-filled with silk from the filling engine; the other rods of silk are turned, and so the process goes on, each revolution presenting a half-section of completely dressed silk to the workman and a half-section to turn.

A method of stripping the silk from the rods is shown in Fig. 59, which represents the large drum travelling in the direction as shown by the arrow. A is a cloth laid on the top of the dressed silk and affixed to the roller D. This rod is placed under the extreme end of the first film of silk E and revolved in the direction of arrow F, which causes the silk to be wrapped round the rod and pulls the entire length of silk off the rod which is in the groove C. At the same time the first film entangles the second film, the second the third, and so on, and as the workman rolls the rod D round and round he thus draws the silk off the rods in the grooves and wraps it inside the cloth A, so forming what is called a "nappe" of silk.

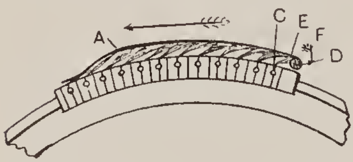


FIG. 59.—Rod stripping.

The speed of the circular frame varies considerably in accordance with the nature of the silk to be dressed. The large drum may make from one revolution in 5 minutes to one revolution in 10 minutes. The first working cylinder may be run from 70 to 80 revolutions per minute, and the second cylinder from 120 revolutions, the speed of the latter necessitating a shorter toothed comb than the former. This extra speed and finer and shorter wire are most important, for without them the dressed silk would be nibby and full of noils. The relative speed of the working combs to the speed of the large drum needs constant watching, as the secret of the successful use of these machines would appear to be that of adapting the workers to give only just enough dressing to open out the silk and clear the nibs. Too much dressing can be given, either by settng the wire too close to the wooden sliders in the large drum and so cutting the silk, or by giving such a great speed to the combs that they tear much of the silk

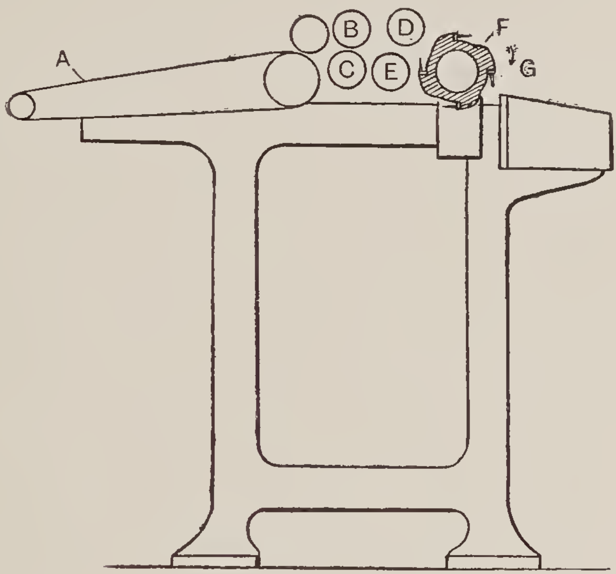


FIG. 60.—Lap filling machine.

out of the sliders and also punish the fibre too much, making it extremely tender and short in length. On the other hand, too slow a speed would mean perfectly useless silk, for the fibre would not be combed through. It could, of course, be subjected to another combing by allowing it to go round again in the large drum, but the production of the machine would in that manner be decreased and the cost of the resulting dressed silk increased. The accumulation of silk on the working cylinder Z (Fig. 58) is often composed of such short fibre that it is put on one side as noil; but the silk on the working cylinder Y (Fig. 58) is long in fibre, and after being stripped off the combs by means of stripping rollers—which deliver it in the form of a lap—it is put through a small filling engine (Fig. 60). This machine can be used for refilling the strips or laps off the large stripping drum of the flat dressing frame, and its construction is quite simple.

A is the feed sheet on which the lap of silk is placed, and by which it is carried to the rollers B, C, D, E. The last pair of these rollers revolve more quickly than the first pair, thus drafting the silk and loosening the fibres. The drum F is furnished with four rows of combs G, and revolved in the direction shown by the arrow at a speed greater than the delivery of silk from the feeding rollers. The combs thus draw on to themselves a film of silk at each revolution of the drum, and when the attendant considers them full, the machine is stopped and the strip taken off by means of the sticks described previously with the silk-filling engine. The attendant of this small filling engine also looks after the stripping of the working cylinders of the circular dressing frame, and keeps the dresser fully supplied with the sticks of filled silk.

The dressing frames are worked in pairs or fours, one—called the first frame—receiving the silk from the filling engine and dressing first and second lengths, and the other receiving the strips from the second lengths and dressing out of them the third to the fifth lengths. Some qualities of silk are only dressed into three lengths, and the remaining strip is taken and combed. A week's work on four machines is enormous compared with the English standards of flat-frame dressing. A first frame (circular) will yield of dressed silk from 400 to 500 lb. per week, a second frame from 200 to 300 lb., a third frame from 150 to 200 lb., and a fourth frame about 100 lb. per week of fourth and fifth drafts, the cost per pound being 2d. to 4d. It must be remembered that the foreign rate of wages is low, whilst the hours worked are long—say twelve hours per day to the English ten hours.[1]

A set of four frames appears to be the most economical manner of arrangement, and the method of work would then be: The large filling engine supplying the first dressing frame; the first dressing yielding first drafts, and the strips being refilled and supplied to the second frame; the second frame yielding second drafts, and the strips refilled and supplied to the third frame; the third frame yielding third drafts, and the resulting strips supplied to the fourth frame, which yields fourth and fifth drafts, the last strips being noils.

Continuous flat dressing frame.—This is of recent invention, and is designed to work on the same principles as the ordinary flat frame, with the large production of the circular frame. Fig. 61 gives the end elevation, Fig. 62 the side elevation, Fig. 63 the plan of one of these machines, and Fig. 64 a photograph showing the machines in work. A, B, C, D are four endless chains or sheets passed around the rollers W, X, Y, Z. These rollers are mounted in adjustable bearings E (only shown on section W) on the framework of the machine. The sheets around the rollers W and X are supplied with combs F, exactly like those used on the ordinary flat frame, but the sheets around Y and Z are supplied with both cards G and combs F. Each pair of rollers carrying the sheets of combs are adjustably arranged to different heights, so that the sheets can be inclined at an angle to the silk S passing under them, the second endless sheet B being closer to the silk than the first sheet A, and the third C closer than the second, and so on.

The silk from the filling engine is placed in small boxes H, which are fitted up with sliders and boards K like the inframes of the flat dressing frame—in short, the box is a small inframe. Underneath the box is fixed a rack which

[1] It must be remembered that hours of labour on the Continent have been reduced since the war, and wages increased at least double on pre-war costs.

gears into the worms L on the shaft M. At each end of the frame is a turn-table N, and between each frame a similar turn-table.

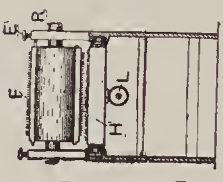
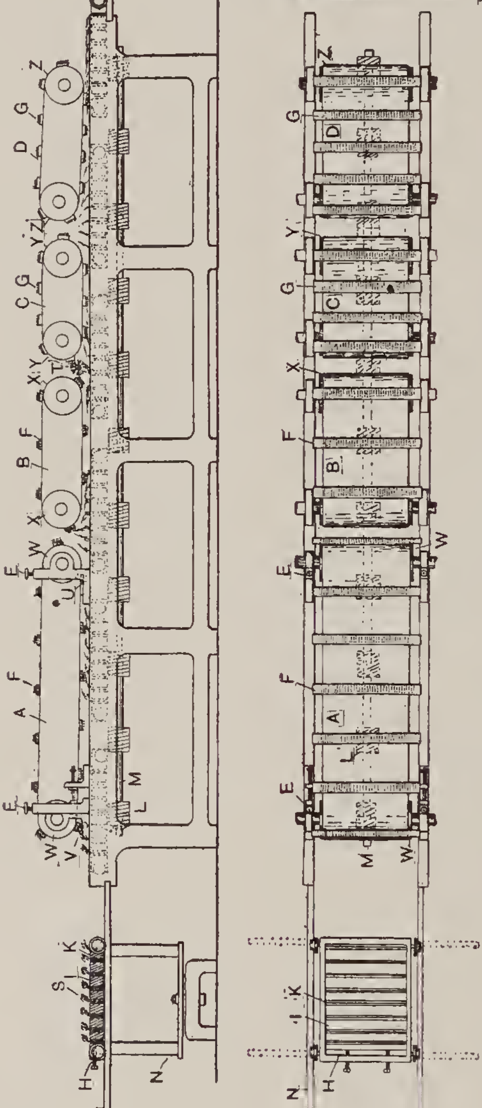


FIG. 61.—Continuous dressing frame (end view).



FIGS. 62 and 63.—Continuous dressing frame (plan and side elevation).

Opposite the turn-tables and between the frames is an automatic screwing-up machine to enable the attendant

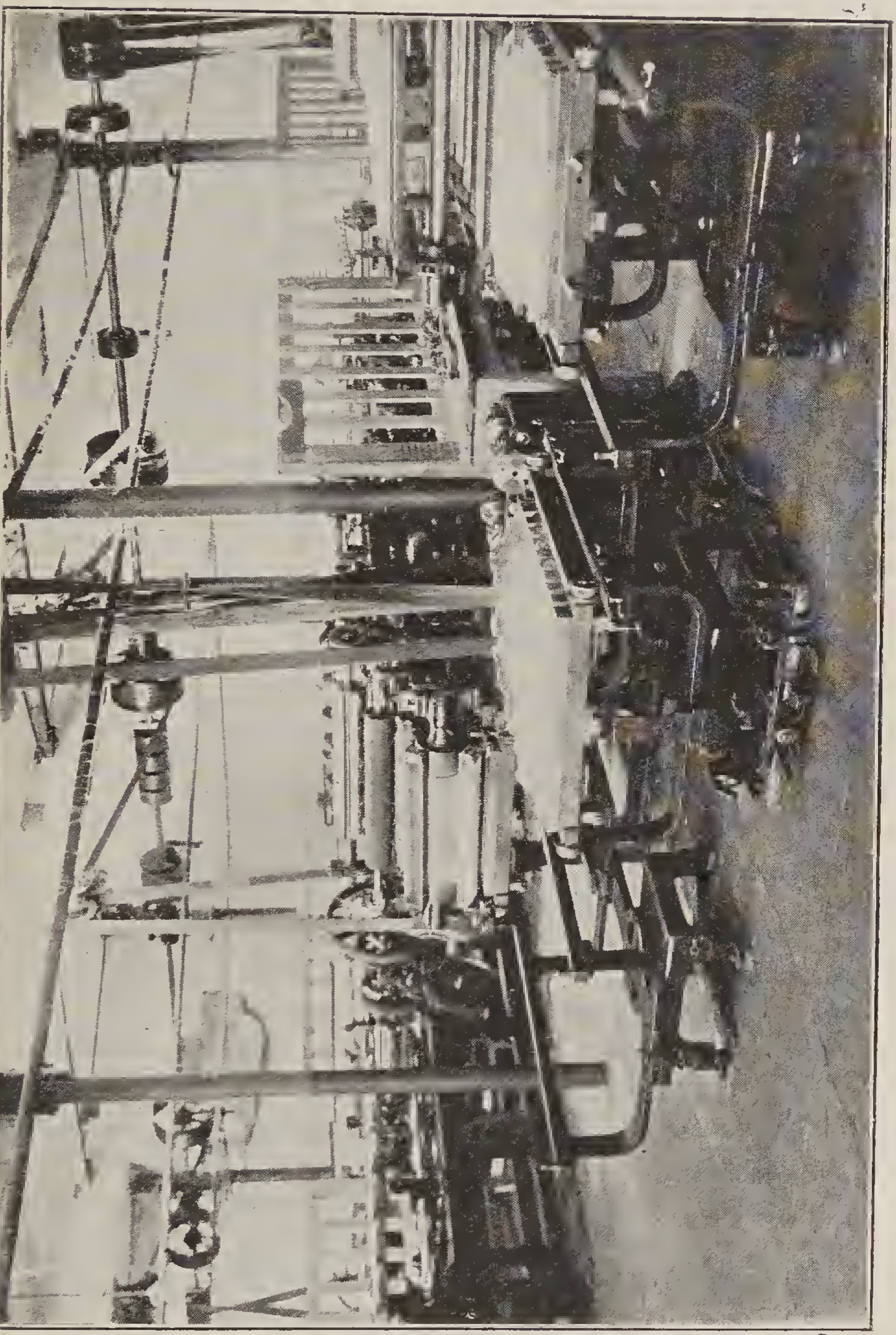


FIG. 64.—Continuous dressing frame.

to screw up the boards of filled silk in the boxes. It requires six or seven boxes to fill the dressing frame (as shown by dotted lines). The action of the machine is as follows: The boards of silk are inserted between the sliders in the ordinary way whilst the box is on the turn-table between the frames. The sliders and boards are nipped tightly together by the screwing-up motions, and then the box is moved on to the turn-table N (at the left), whence it is moved forwards so that the toothed rack comes in contact with the worm L. The revolution of the worm draws the box forward, so that it passes slowly underneath the combs and cards on the endless sheet, and the series of worms propel the box forward from end to end of the frame. A second box is placed close behind the first, and a third behind the second, and so on until the frame is full.

As the silk fibres come in contact with the combs at the point V they are laid hold of by the combs and drawn through them, thereby combing the fibres thoroughly in travelling the length of the endless belt. As the combs are farther away from the silk at point V than at point U, the silk is very gradually and gently combed and dressed. Each projecting tuft of silk, in passing clear of combs at U, is naturally drawn over by such combs as they travel around the bend of the roller W, and therefore, when the tufts reach the endless sheet B—which is travelling in the opposite direction to the sheet A—the combs on the sheet B lay hold of the opposite sides of the tufts, which are thus combed and dressed a second time, but on the reverse side. After passing under the second sheet B the tufts are turned over by the wiper brush T, and then the cards and combs on the third sheet C operate on the silk to remove the nibs and noils. The roller Y operates in the same manner as the roller W, so that the reverse side of the silk is carded and combed in section D.

By thus travelling the silk horizontally under and in contact with the combs and cards a complete dressing is given to the fibres in passing once through the machine. The boards of silk are turned in the usual way on the turn-table between the frames at the right-hand end, and the box is then pushed into the frame alongside the first frame, which repeats the process as described, so that when the box reaches the turn-table at the end of the second frame, both ends of the tufts of silk are dressed. The dressed

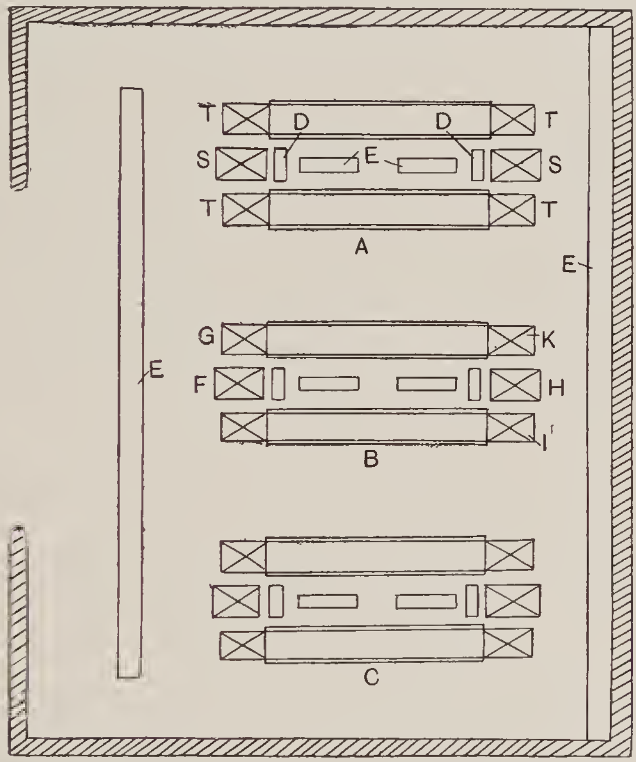


FIG. 65.—Continuous dressing frame (plan of set of frames).

silk is removed by the attendant, the box is refilled with undressed silk, and is then sent forward to complete another circuit of the machines. Whilst the first box has been travelling, fourteen or fifteen other boxes have been filled and propelled forward one behind the other, so that there is always a constant supply of dressed silk being delivered by the frames. The fibre removed by the working combs is pressed down to the roots by brushes and stripped in the usual way, making first to seventh drafts in the mode of the flat dressing frame.

The most economical method of working continuous frames is shown in Fig. 65. This gives the plan of six machines arranged in pairs A, B, C. At each end of each frame is a turn-table T, and between each pair at each end another turn-table S. Opposite each of the latter turn-tables is fixed the automatic screwing-up machine D

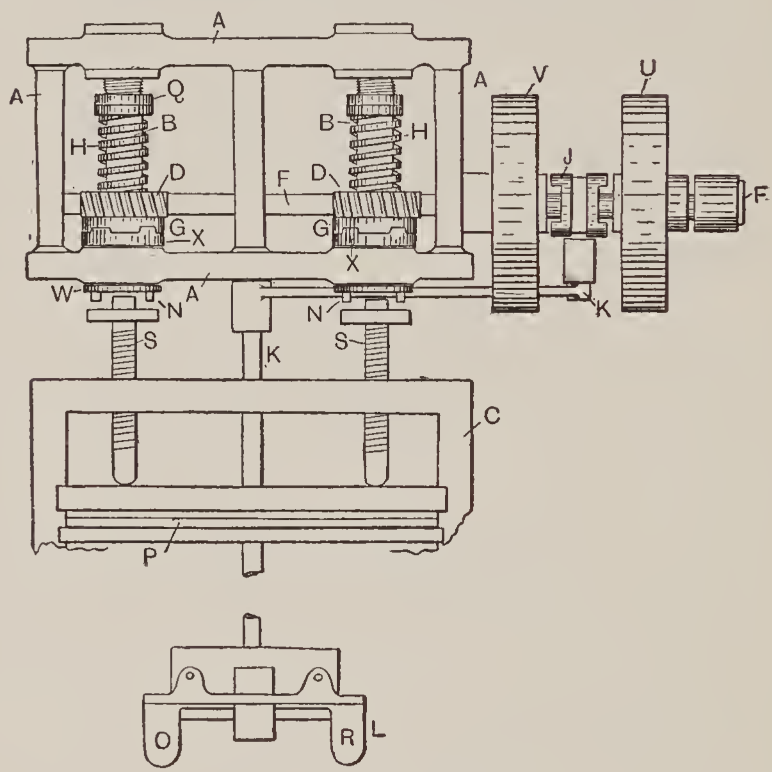


Fig. 66.—Screwing-up machine.

(shown also in Figs. 66 and 67). At the end of each frame or row of frames, and between each pair, is fixed the tabling E, which forms a place for the storage of dressing boards, empty and full, and for "turning" the silk. The pair of frames A receive the strips from the filling, and dress first drafts. The strips from frames A are filled into the boxes of the frames B, which dress out second and third drafts. The strip from the third draft is delivered to the frame C, which dress fourth, fifth, and sixth drafts.

Each pair requires two attendants to strip the combs and one attendant at each end. One, called the putter-in, is stationed at F, and places the boards of silk into the box or inframe, which he then puts in contact with the worm, which carries it forward under the combs. He then transfers his attention to the delivering end G of the opposite frame, which delivers a box full of completely dressed silk. This he empties out and refills with silk for dressing. The other attendant at H receives the dressed silk from the finishing end I, turns the silk in the board,

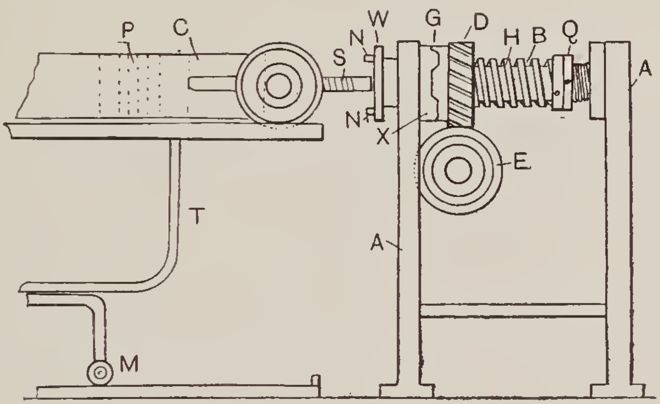


FIG. 67.—Screwing-up machine

and pushes the box under the frame at K, whence it travels again to the putter-in. The time occupied by a box in travelling the circuit of the pair of frames is about one hour and ten minutes, so that the action of the combs on the silk is very gentle.

A box of dressed silk is delivered at the finishing end of each pair every four or five minutes, and therefore the production of the machine is very great. The quality mentioned previously in flat dressing would yield about 800 lb. of dressed silk from the three pairs of frames per week of fifty working hours With a good quality of gum silk the production of finished silk would be 900 lb. per fifty hours. Tussah silk can be worked to show a production of 1200 lb. per fifty hours. Schappe silk of fair quality will yield the last-named weight, and the quality of dressing—both in length of staple and yield of drafts from the weight filled to the machine—is better than that produced by either the circular or the flat frame. Foreign rate of wages and hours of work make the continuous-frame system the cheapest method of dressing yet known.

Other systems of continuous frames have been attempted, but the one described is the only one which gives a better yield of drafts than flat-frame dressing. The "faller" principle of propelling the silk under combs and cards is not good, for two main reasons: First, the automatic locking arrangements fail to hold the silk tight in the boards; and, second, the difference in the wear and tear of each respective faller or book-board causes them to be unequal in height, and therefore the working combs and cards dress the silk unequally. Some is left nibby and noily, and some is cut short, the latter because the board of silk is too high, and the former because it is too low, in relation to the working combs and cards. An absolute essential for a successful dressing frame is tight hold of the silk in the boards; and a more important one still is extreme levelness of the series of boards, for each board must be kept level with the sliders. In flat frame dressing the inframe is planed and levelled from end to end, and as each inframe works under its own combs, the keeping of the boards right is not a very difficult matter. For a continuous frame, the boards in each box must be level, and every box must be exactly the same height, so that each box gets exactly the same combing and carding.

During last few years further improvements have taken place in continuous silk dressing frames. The objects being to obtain the advantages of the circular dressing frame such as—

1. The fibre depending whilst undergoing dressing operation.

2. The ability to exhaust dust, dirt, and chrysalides, leaving fibre clean after dressing.

Also to obtain the largest possible output, such having been increased ten times at least during 1918 and 1919.

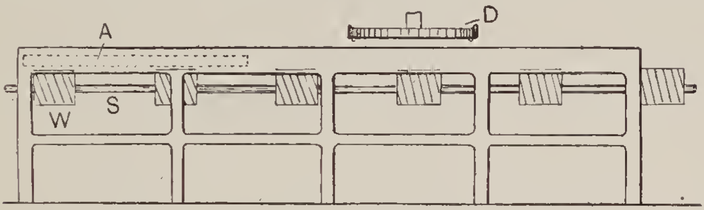


FIG. 68.—Planing machine for bookboards.

A still further advantage is the preparation and selection of the short fibres of silk for a combing process.

The boxes holding the silk for dressing in such con-

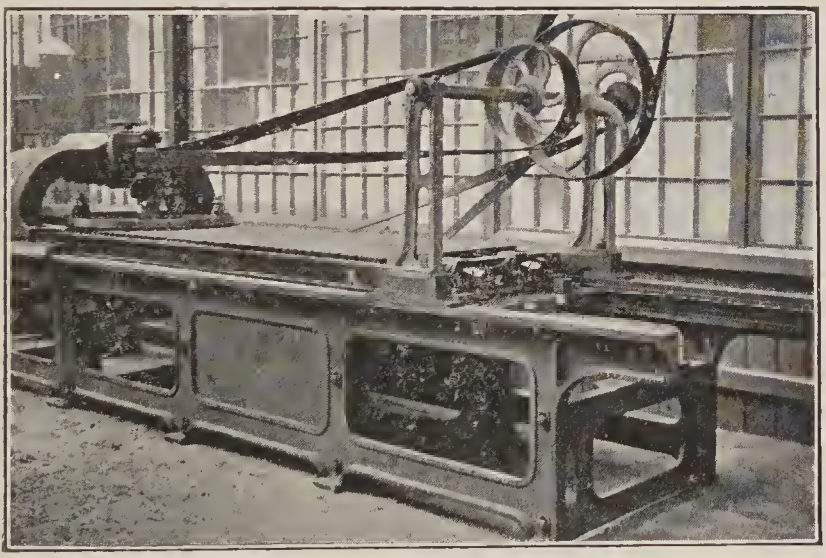


FIG. 69.—Planing machine for bookboards.

tinuous machines must be all level and woodwork same height in each box.

This is attained by use of the planing machine shown in Figs. 68 and 69.

Planing.—The boxes are fastened down on the frame A (shown by dotted lines), which frame, by means of the worms W on the shaft S, is propelled to the rear end of the machine and passes under the disc D. This disc revolves at a great speed, and with its cutters planes the woodwork in the boxes absolutely level. The disc can be raised or lowered to accommodate any depth of frame, but, when once "set," all the fourteen boxes to fill a dressing frame are run through; thus each box is level one with the other, and perfectly dressed silk can be obtained in each box.

Screwing-up machine.—The working of the automatic screwing-up machine is as follows: Fig. 66 is the plan, and Fig. 67 the side elevation. A is the frame-work of the machine, while B are spindle shafts corresponding in number and distance apart to the compressing screws S in the inframes C (the inframe is shown in part). Keyed on the spindle shaft is a toothed wheel D engaging with the worms E secured on the main driving shaft F. Each spindle B is provided with a clutch G, kept in gear by springs H, the pressure of which can be regulated by the nuts Q, so that when the pressure reaches a desired maximum the clutch G will disengage itself or slip.

The main driving shaft F is driven in either direction by driving pulleys U and V, which are controlled by the reversing clutch J, which is worked by the lever K from the foot lever L.

The inframe is placed on the turn-table T, which is mounted on runners M to enable the compressing screws S to effect an engagement with the pins N on the part of the clutch W. When in position the attendant presses one foot on the lever L at the point O, which causes the clutch J to engage with the pulley V which traverses the shaft S, thus rotating the clutch G and screws S, and compressing the bookboards P. When the pressure is sufficiently great to overpower the spring H, the clutch G will slip, and the free part X of the clutch G will cease to rotate. Depression on the side R of the foot lever operates the pulley U, which turns the clutches and screws the opposite way, thus releasing the bookboards from the pressure, to enable the attendant to take them out to remove or turn the silk.

It will be noticed that the production of all kinds of dressing frames depends upon the number of boards which can be put through them, and as silk in the commoner qualities is always inclined to work thick and fluffy in the short drafts, the number of boards of silk has to be greater in the "short frame" than the "long frame," consequently the production of the "short frame" really rules the production of the set of frames. This is well illustrated by the following figures.

In flat frame dressing, 3 oz. of filled silk being placed in each board of the first frame, a first frame attendant will handle 2376 boards per fifty hours, a second frame attendant about 4300 boards per fifty hours, and a third frame attendant 4600 boards per fifty hours, the latter equaling about 92 boards per hour.

The continental circular frame user, however, only fills about 1 oz. per board, and therefore to obtain a large production of dressed silk a larger number of boards or sticks of silk must be turned per hour. For a first frame the number would be 125 per hour, a second frame 150 per hour, whilst a shorter draft frame would need from 200 to 250 turning per hour.

The continuous flat frame, working the same silk as the flat dressing frame, gives at least the same number of boards per hour as the circular dresser, and it can be easily proved that the saving to an English silk spinner using the continuous machine is 50 per cent. in cost per pound of dressed silk. The continental dresser cannot fill a large weight per board or stick to his machine, because the severe action of the combs on a thick film of silk would damage the fibre, cutting it short and spoiling the yield. A great compensation for the thin filling—1 oz. per board—comes by reason of the large percentage of first drafts which this thin filling gives. In all dressing, a thin film will yield better and dress easier than a thick one, and a schappe silk will dress better thin than a fully discharged silk, because the latter has to be run hard into the combs to clear the nibs of the fibre. A discharged silk, therefore, needs a certain amount of "body" to cause it to spring to the combs and cards of a flat frame, which are always pressing down the silk on to the sliders. If the silk lies too flat it will not clear unless the combs are run through the silk and into the wood beneath, which of course damages the points of the combs and cards, rendering them useless, and also spoiling the woodwork—sliders and bookboards—of the frame.

The diagrams in Fig. 70 show the principles of dressing in each class of frame.

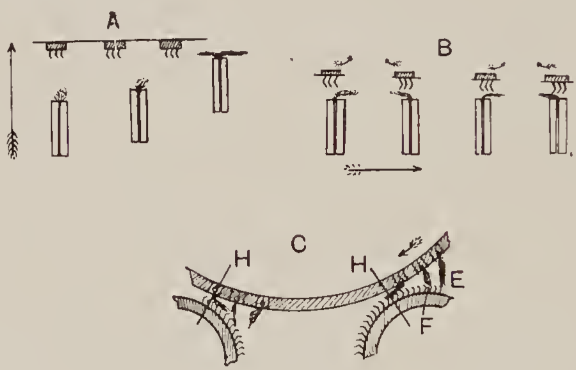


FIG. 70.—Diagram of dressing frames action.

In flat-frame dressing, as shown at A, the films of silk are *raised up* (see arrow) into contact with the combs, which therefore comb through the silk, beginning at the point of the fibre and dressing half-way through the film, after which the frame must be let down, turned half round, and the under side of the silk film turned upwards for combing. The same operations must be repeated for carding out the nibs. During the raising up and down and turning and filling of the boards of silk, the combs and cards are not working, and during that period the machine may be classed as a non-producer.

In the continuous flat-frame dressing, shown at B, the films of silk travel *forward* gradually into closer contact with the combs, and under each section the silk is reversed automatically, every operation of the flat frame being repeated; but the continuous frame is always delivering dressed silk.

In the circular frame, of which the working portion is shown in part sectionally at C, the tufts of silk pass the comb very quickly, the points of contact varying with the length of fibre, as shown at E and F, and all the combing is done between points of contact and the nip H of the large drum and comb drum. As there are only two working combs, each working in opposite directions, the film of silk is only combed on each side *once* instead of *twice* by the other methods of dressing, and therefore the circular frame has to be more severe in its action on the silk fibre than in flat dressing, to ensure the silk being properly dressed. The circular frame is also always delivering dressed silk.

Combing machines on the Heilmann and Noble principles have often been tried for silk dressing, but the latter are useless for silk. They have no mechanism giving sufficient grip of the end of silk not being combed to enable the portion projecting for combing to be adequately combed. The Heilmann principle will comb short fibred silks very well indeed.

The dresser keeps each draft separate, packing them usually in tins preparatory to the next operation. The first four drafts are the most in quantity, and also the most valuable, these being used by the "long spinner." The fifth, sixth, and seventh drafts are called shorts, and are used by the "short spinner." The noils are either combed in order to obtain another length of silk out of them, or they are worked into yarn on the same system as wool. If combed, the resulting sliver from the noils is used in short spinning, and the noil itself—called exhaust noil—is also put through the woollen spinning system. After the drafts leave the dresser they must be examined to see if they are properly dressed, and also to remove any threads of cotton, hard twisted ends of silk, pieces of hemp, and other deleterious matters not removed by the picking process previously described.

CHAPTER VIII.

SILK WASTE DRAWING OR PREPARING MACHINERY.

Long Spinning.—The largest percentage of weight of dressed silk being in the first four drafts, "long spinning" is the most important branch of the spun silk industry. It derives its name from the fact that it deals with the longest fibres produced from silk waste, and also in contradistinction to "short spinning." Originally all silk waste was short spun—*i.e.* combed or dressed in the gum state —the drafts being then taken to a cutting machine (built like a hay chopper) and cut with knives into lengths of 1 to 2 in., thus making the fibres an equal length as far as possible. The material was then boiled and afterwards beaten, scutched, carded, drawn, spun, etc., in the same manner as cotton. The cutting of the fibres and the action of the cards spoilt the lustre of the silk, and in process of time spinners found that the most efficient mode of dealing with the fibre and enhancing its value, by reason of its increased lustre and strength, was to boil the silk before dressing, and put the resulting long drafts through spreading and gill-drawing machinery very similar to a worsted plant. Like all new systems, it took time to become general, and meanwhile the old style became known as short spinning—really "cut-silk spinning"—and the new as "long spinning." Nowadays the cutting of silk is almost done away with, and most spinners, having only the long spun machinery, sell their shorts—*i.e.* fifth, sixth, and seventh drafts—which are bought by the few remaining short spinners, and scutched, carded, drawn, and spun as described later.

The lengths of fibres in the various drafts vary very much. For instance, a first draft of good gum waste like China will have fibres from 2½ to 7 or 8 in. in length, whilst the seventh draft would show fibres 1 to 3 or 4 in. long.

What may be called a common quality (say steam waste) will show fibres as follows:—

First drafts from	2	to	6	in.
Second ,,	2	,,	4	,,
Third ,,	1½	,,	4	,,
Fourth ,,	1½	,,	3	,,
Shorts from	½	,,	3	,,

These different lengths of fibre cause much trouble in the drawing departments of a silk mill, and until recent years each draft was spun into a separate yarn. Thus one quality of waste was spun into what were known as first-draft yarns, second-draft yarns, third-draft yarns, and so on, the longest draft being sold for the most money, on account of its superior strength and lustre. As competition increased, spinners found they could draw first and second draft yarns together for many purposes without materially damaging either strength or lustre, and from that they progressed until nearly every spinner makes a yarn for some purpose or other which contains all four drafts drawn together. They can be made into a good strong level yarn, quite good enough for any ordinary weaving purpose, so long as care is taken in the drawing not to allow the shortest fibres to run through in lumps. As strength is needed, care must be exercised not to break too much the long fibres. Now, as even first drafts contain such great differences in length of fibre, it can easily be understood that machines which will satisfactorily cope with first drafts can only be wrong in some minor details for all four drafts, and these details are chiefly in diameters of rollers and length of "reach"—that is, distance between back and front rollers. The principle of drawing is to reduce a thick portion of silk down to an end so small that it can be spun into a thread without an excessive draft, and at the same time to level it so that the thread is all one thickness. This is done by a pair of rollers revolving slowly, taking the silk in, and feeding a pair of front rollers revolving quickly, thus drawing the silk out. To put it another way: If 200 fibres are lying side by side, each 6 in. long, drawing makes the fibres into a thread, say 60 in. long, with 20 fibres deep This operation is repeated a sufficient number of times with a number of ends behind the back rollers to make a sufficient number of doublings, until the silk is brought down in thickness to

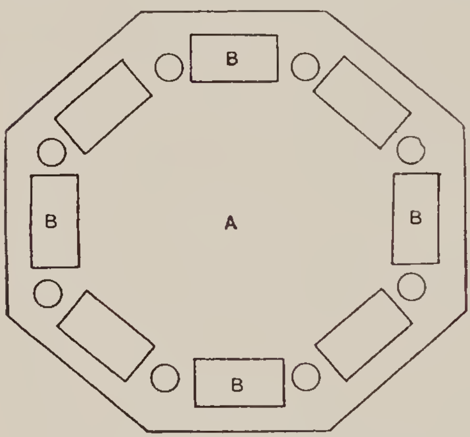


FIG. 71.—Silk picking table.

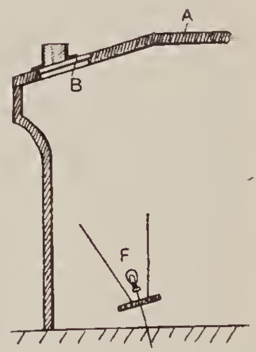


FIG. 72.—Silk picking table (side section).

a thread or roving sufficiently fine to be spun, and at the same time so level that it is as near as possible all one thickness from end to end. As there are many different kinds of drawing frames, we shall describe only those which have been found most suitable for a general trade, taking long spinning drawing machinery first, and then short spinning drawing machinery, each up to the point of spinning, whence all kinds of yarns undergo much the same treatment.

Picking drafts.—If the silk to be spun is free from extraneous matters, such as small portions of cotton, China grass, straw, and hairs, it would be passed to the "weigher";

but many silks are not free, and therefore the first process is really "picking" or examining the silk for bad dressing and foreign fibres. For this purpose, in a dark room is erected a picking stand round which eight persons can sit. Fig. 71 shows a plan of this stand, and Fig. 72 a sectional elevation. The arrangement is as follows: A is the framework of the stand; B glass squares let into the framework, the top of the frame and glass being exactly level and smooth; C (shown only in Fig. 73) are rods of smooth hard wood hinged at one end D, and held down at the other end by the spring catch E. Under the frame is either a gas light or an electric light F surrounded by reflectors to throw up a strong light through the glass squares

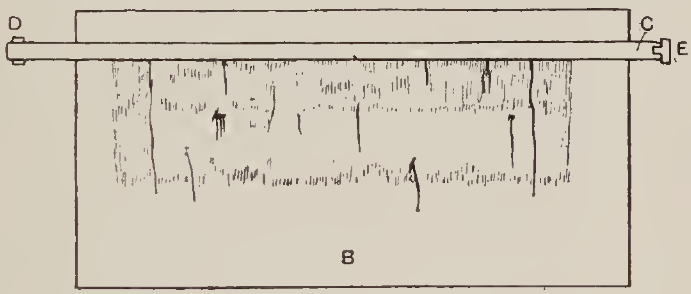


Fig. 73.—Drafts.

Opposite each square is seated a girl having a tin of dressed silk by her side, who places a portion of it under the wood rod shown in position in Fig. 73, which illustrates also the square of glass B. Any pieces of straw, cotton, hair, or other coarse thick fibres show dark (like the dark lines in the illustration) against the light, and are easily seen by the girl picker and taken from the silk. Any portion of very short silk is shown up also, and is taken out, as are nibs and badly dressed silk. After picking, the silk is replaced in a tin and conveyed to the "weigher."

Weighing.—This is usually done by girls, who sit at a table on which are placed, at regular intervals, small beam scales. They weigh the dressed silk (keeping each draft separate) into 3 oz. parcels, each 3 oz. being most carefully weighed and wrapped in soft paper, tied up with string or fastened with an indiarubber band, and thence handed, a certain number at a time, to the silk spreader.

Long spinning drawing machinery.—Silk spreading is the first of a series of silk "gill or faller" drawing machines. A gill drawing machine consists usually of a pair of back rollers revolving slowly, and a pair of front rollers revolving quickly, while between is a set of gills or fallers carrying the silk from the back rollers to the front. The principle of all the machines is the same. The back rollers receive the silk, deliver it to the fallers, which rise one by one, pierce the silk, and travel forward to the front roller. The fallers then drop, and are carried back to the rising end, and again raised into the silk.

The fallers are bars of steel, Fig. 74, into which are fixed fine steel pins. They are travelled forwards by means of two screws, between the threads of which they are run. When the fallers come to the end of the screws they drop down (being helped in their drop by cams at the end of each screw) into the thread of another pair of screws revolving the reverse way, and so carrying the fallers back underneath their previous traverse. When arrived at the end they are lifted up by means of cams into the top pair of screws, and so recommence their journey. The front rollers draw the silk quickly through the fallers, thus making it into a much thinner ribbon or film of silk than when it was delivered by the back rollers to the fallers. This drawing through the pins lustres the silk and straightens or lays the fibres parallel to each other. If the fallers travel more slowly than the circumference of the bottom back roller revolves, the silk will lie on the top of the pins, and thus will not be drawn through them when they reach the front roller. If the fallers travel faster than the back roller, they have a tendency to drag the silk and break it. Therefore a choice must be made of two evils, and practice has shown that the latter method is the best. The back rollers are movable so as to allow them to be drawn away from the fallers for long-fibred silk, or set closer for short-fibred silk. The pins of the fallers are coarsely set in the first machine, and the difference of speed between back roller and faller must only be very slight. Long silk needs freedom between roller and faller to ensure as little breakage as possible. Short silk offers no resistance to the pins as they rise, and therefore the fibres lie on the point of the pin. Satisfactory results can only be attained by the pins piercing through the silk. The easiest test is to feel at the silk between the back roller and the fallers, and if it is stretched very tight to put back the rollers; if it is slack and riding on the fallers, the rollers should be brought forward. Those in charge should never be satisfied until the silk is well in the pins, and they should in no case resort to artificial means of forcing the silk down. Some drawing overlookers fix a brush over the back portion of the drawing box, thus forcing the silk into the pins, but at the same time breaking the fibres.

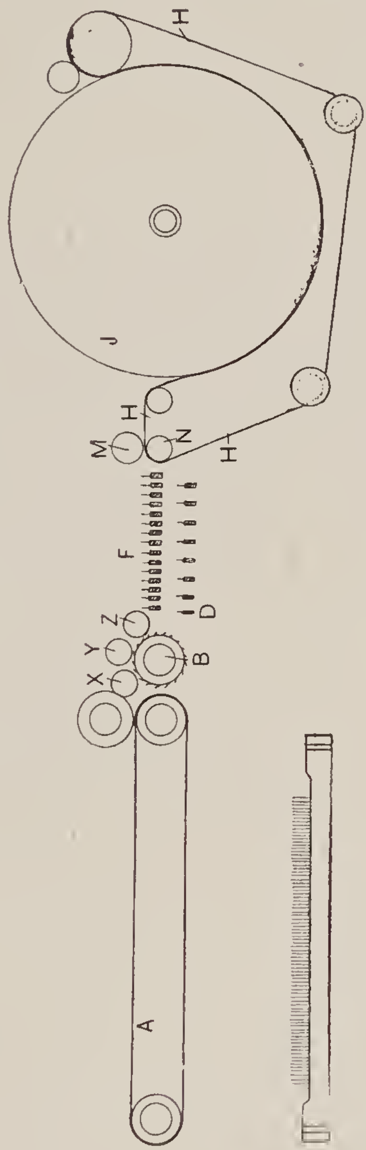


FIG. 75.—Gill spreader.

FIG. 74.—Faller.

Fig 75 shows side elevation of the gill spreader. A is a travelling leather endless belt, on which the draft of silk is spread in the manner shown in Fig 76. The silk is travelled into touch with the porcupine roller B, and held firmly down on the teeth of this roller by the small rollers X, Y, Z. It is conducted from the porcupine into the fallers F, which, rising from D, strike into the silk, and carry it forward to the receiving and drafting rollers M, N. As these travel eight or ten or more times faster than the fallers, they draft or draw the silk through the pins, thus making the silk into a film eight or ten or more times thinner than when it entered. The endless leather sheet H conveys the silk to the large wooden drum J, which carries it round on its face until the 3 oz. parcel has all been spread on the sheet A, travelled through the fallers on to the drum, and so made a thin film of silk about 8 or 10

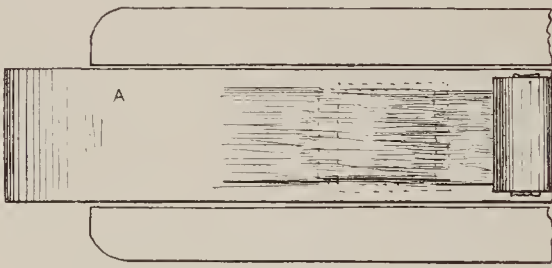


Fig. 76.—Silk spreading.

in. broad and the length of the circumference of the drum. When complete, the silk, now called a "lap," is cut across the drum in the direction of the axle, and wound up as it leaves into a small ball in readiness for next operation. A good spreader will spread the silk thinly and evenly on the sheet A, the fibres lying straight and overlapping as shown in plan by the dark lines in Fig. 76. If she is allowed to put the fibres sideways, they enter the pins of the fallers in that way, and when that portion of the silk reaches the drawing rollers M, N, they either pull the fibres over the tops of the pins or break them asunder. If the former happens, the lap contains a lump of thick silk which needs more drawing in the following drawing machinery, which most probably never gets thoroughly drawn, and thus makes a foul yarn. If the fibre is broken, then short silk is being formed, which weakens the thread and deadens the lustre of the yarn. A careless spreading machine attendant can easily spoil the work of the dressing frames and render it impossible to make a level and perfect thread.

Re-lapping.—For the purpose of still further straightening the fibres of silk, the lap is often put through the spreader, thus re-spreading or re-lapping it; but this pro-

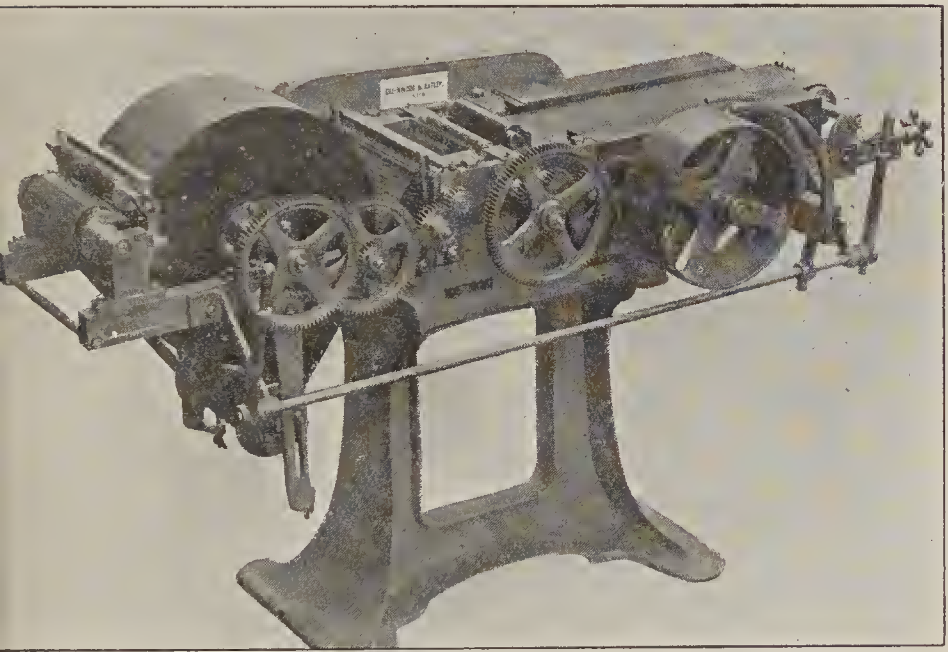


FIG. 77.—Gill spreader.

cess is only really necessary for the shorter drafts. Fig. 77 is a photograph of this spreading frame.

Sett frame.—The silk, after going once or twice through the spreader, is next made into a sliver by being passed through the sett frame, which consists of a feeding endless leather belt, back rollers, and fallers similar to those previously described; and front drawing rollers, which deliver the silk into a pair of pressing rollers, from which it emerges in the form of a ribbon or sliver, and drops into a long can placed beneath the delivery rollers. Fig.

78 is a photograph of the sett frame. Very often these machines are fitted with a bell or stop motion to warn the attendant when a predetermined number of yards has

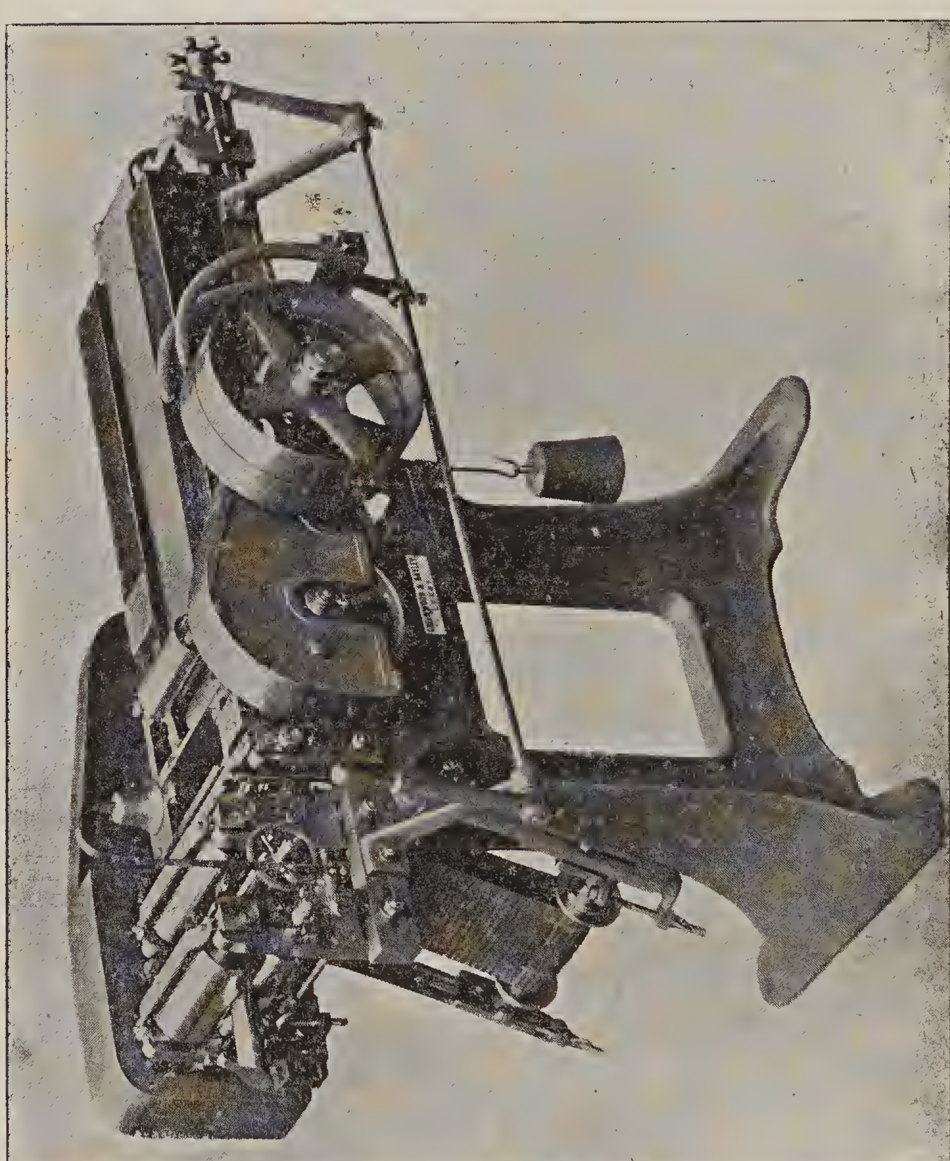


Fig. 78.—Sett frame.

been delivered into the can, and if the weighing and spreading have been properly performed the respective lengths should be nearly the same weight. Sometimes the sett frame is fixed on the same gantry as the drawing heads, as shown by Fig. 79, which shows the back of the sett frame and the back of the first head of drawing.

Drawing frames.—These are for the purpose of levelling the slivers, and are similar in construction to the sett frame except for the difference in feed, the one being made to receive the thick lap, and the other to receive slivers varying in number from 6 to 20, according to the number of doublings the silk requires to make it level. Usually

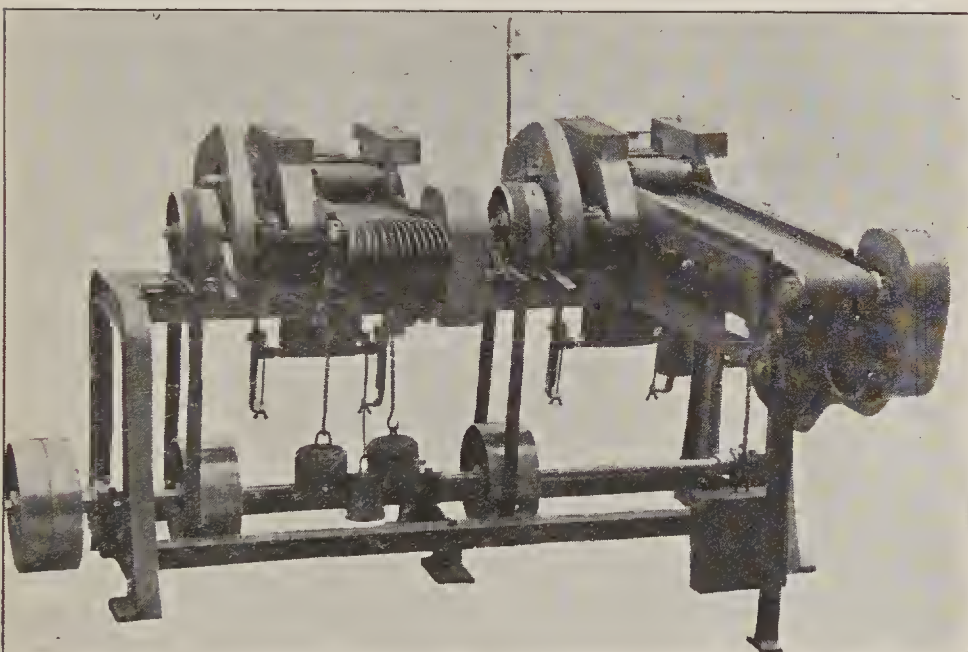


FIG. 79.—Drawing heads.

four drawing heads are employed, called respectively first head, second head, third head, and finisher. An average number of cans of sliver from the sett frame to the first head of drawing will be 10 or 12, and these being put up behind the first drawing box, are drawn out into one thin sliver, which is about the same weight per yard as the one from the sett frame; but it is well to keep rather on the light side. Thus, if 12 ends are up, the draft of the box would be about 14, so that every foot of sliver at the back is drawn to about 14 feet at the front, and the sliver at the front is practically one-fourteenth the thickness of the combined slivers behind. From the front of the first box 12 cans are taken and put up behind the second head of drawing, the same number from the second to the third, again from the third to the fourth, or finisher box. The doublings of the ends or slivers which the silk has obtained in these four heads are then—

$$\text{Ends}\ \frac{\text{1st head, 2nd head, 3rd head, 4th head}}{12 \quad \times \quad 12 \quad \times \quad 12 \quad \times \quad 12} = 20{,}736\ ;$$

and these, with the straightening in the spreading, re-lapping, and sett frame, combine to make a level sliver at the finisher head of drawing. If the work has been well done, the fibres of silk will be parallel, and the sliver will show no lumps or thick places in any portion of its length, so the weight per yard of its length will be accurate.

In all drawing machinery, care must be taken to especially watch the following points: The distance of the back rollers from the fallers should be carefully regulated in accordance with the average lengths of fibre, every box requiring separate setting. The saddles—or bars of iron on which the fallers travel to and fro—need keeping level and a proper length. If too short, the fallers are apt to lock and get either strained or broken. They should be case-hardened to prevent wear. The conductors which are at the end of the saddles are pressed against the ends by springs. As the fallers rise into and drop out of the silk, they press the conductors away from the saddles, and thus glide smoothly up and down between the saddle end and the conductor; and therefore the care of the overlooker is necessary to see that the conductors are tight enough to keep the fallers firm, but not too tight to make them difficult to move up and down. The fallers should always be kept in good repair. It is astonishing how quickly pins get split, broken, and bent. Unless replaced by new ones, the silk is apt to ride on the top of the points, and not to be drawn through the pins; or if the pin is rough when the front roller tries to draw the fibre through, the roughness holds the silk and breaks it, making short silk.

The production of a set of drawing frames varies very much—say, from 250 to 500 lb. per week. Some spinners prefer to work with a light sliver, and others with a heavy one, thus decreasing or increasing production. The heavier production is most suitable for common warp yarns, and the lighter for yarns to be used for weft.

Fig. 80 shows the side elevation of a sett frame, and

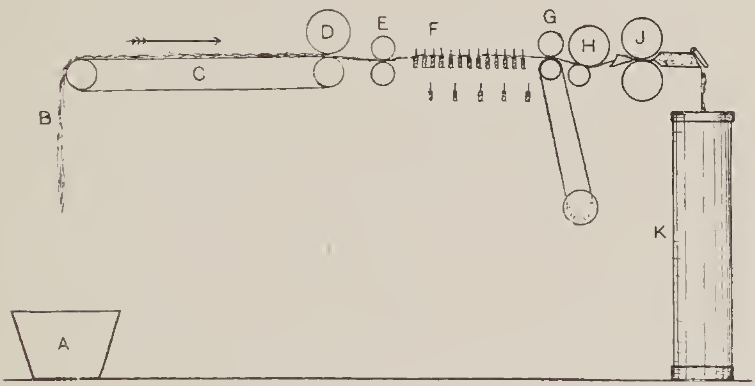


Fig. 80.—Section of sett frame.

Fig. 81 the setting out of a set of drawing frames with a sett frame. A is the can of laps from spreader. B is the silk lap put on the feeding sheet C and passed through the pressing rollers D, the retaining rollers E, the fallers F, the drafting rollers G, the carrier rollers H, delivery rollers J, into the receiving can K. The four heads of drawing are arranged with the first head, receiving cans from the sett frame at L, the second head receiving cans from the first head at M, the third head taking from N, and the fourth head from O, the silk travelling in the direction of the arrows. In putting up the ends of silk behind the drawing frames, it is necessary to see that they are not crossed under each other, as shown at P and Q, for each end should go as straight as possible into the receiving rollers R, S, and T.

Gill roving frame.—The sliver from the finisher head is taken behind a screw gill roving frame (Fig. 82). This is a drawing frame, but instead of delivering its production

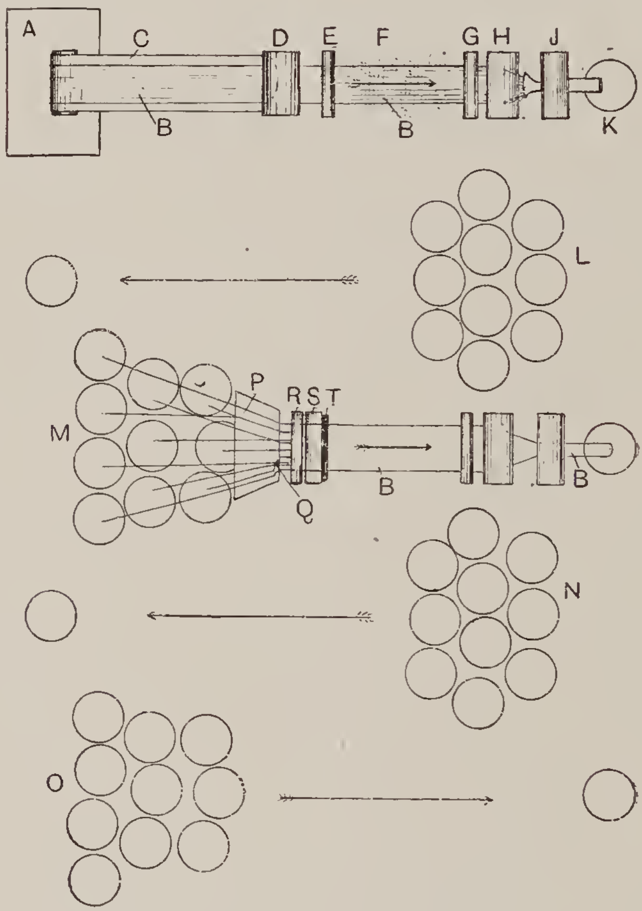


FIG. 81.—Plan of set of drawing heads.

into a can, the end is wound on to a bobbin, thus making the first real twisted thread. Fig. 83 shows side elevation of this machine, where A is the can of silk from the finisher head of the drawing, B is the feed plate, C the guides for conducting the end of silk S under the roller D, from whence it travels over and under the rollers E and F to the fallers G, which, rising and piercing it, carry it forward to the drafting rollers H, which deliver it to the flyer and spindle J, to be wound on to the bobbin K in the form of a soft thick thread.

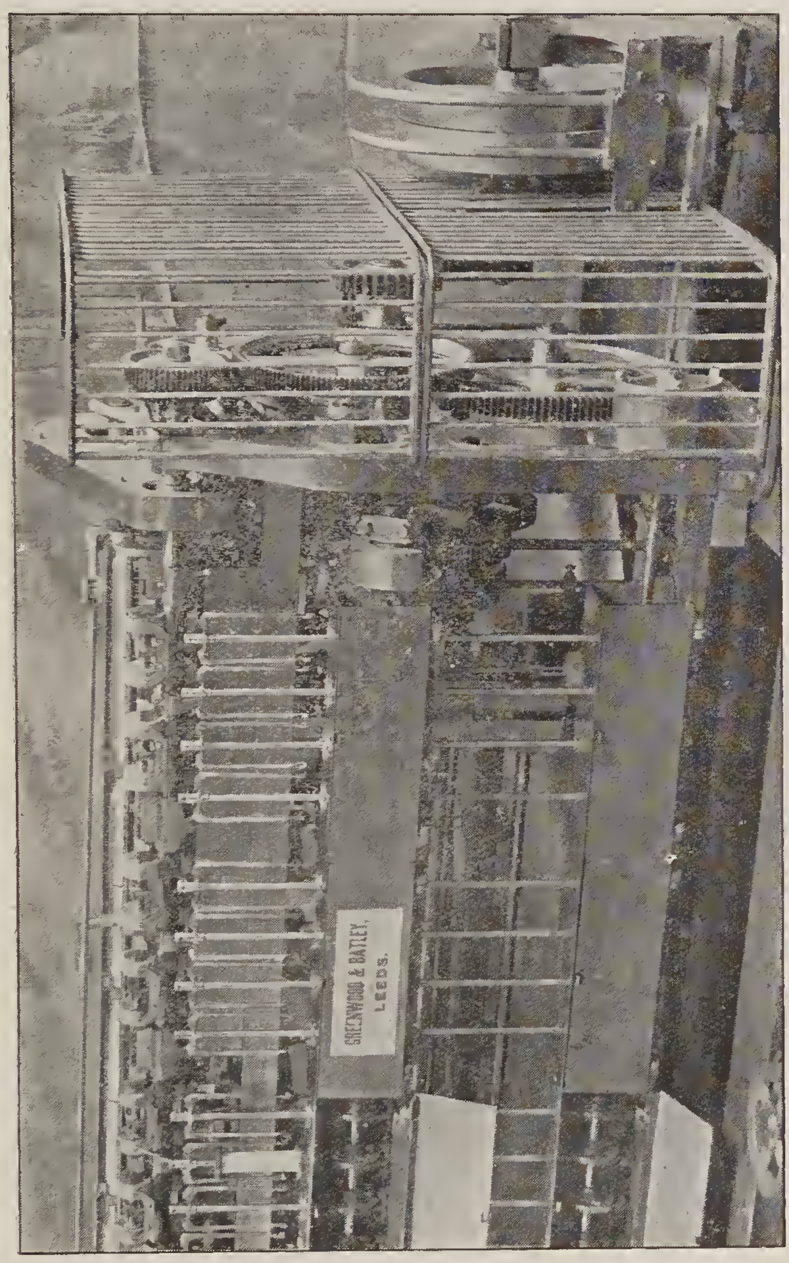


Fig. 82.—Gill roving frame.

The thread produced by the gill roving frame is called the slubbing, and varies in thickness and weight according to the counts of yarn the roving is being prepared to make. A common size is from 1 to 1½ hank—*i.e.* 1 hank equals 840 yds., weighing 1 lb., and 1½ hank equals 1260 yds. to the pound. The finer the yarn is to be spun, the finer the slubbing should be. The twist—*i.e.* turns per inch—put into the slubbing is very small, only sufficient to hold it together. No rule relating to this twist can be given, because what would be hard for one class of silk would be too soft for another, so each overlooker has to work according to his own ideas, and to the nature of the silk under his care. If the twist gets too hard, the next machine will be unable to draw properly, and nowadays there is no

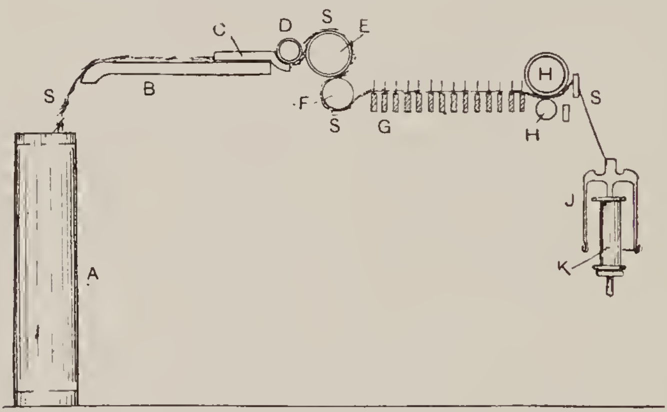


FIG. 83.—Gill roving frame (side elevation).

need to make any mistake on the hard side, because the machines are all made on the cone-drawing principle, enabling the thread to be wound on the bobbin in the softest possible state. The finer the slubbing, the more twist is required. Sometimes, for the purpose of averaging and levelling the slivers more than has been possible in the drawing frames, two ends are put up behind each gill rover spindle and drawn into one. The frames are made twenty-four or more spindles in length, and their fallers are made longer than the fallers in the drawing machinery. If made too long, however, they spring in the middle, and experience has shown that they work well if made long enough to supply three rollers, equalling six spindles. In such a case, the frame is always built in sections, each having its own screws and fallers, and each section put in motion simultaneously by means of a shaft and bevel gearing at the back of the frame. This machine can be so

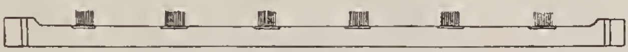


FIG. 84.—Gill rover fallers.

arranged that if any of the fallers get locked, the frame will automatically stop, thus preventing any serious breakdown. The gill rover fallers are only set with pins opposite each drafting roller, as shown in Fig. 84.

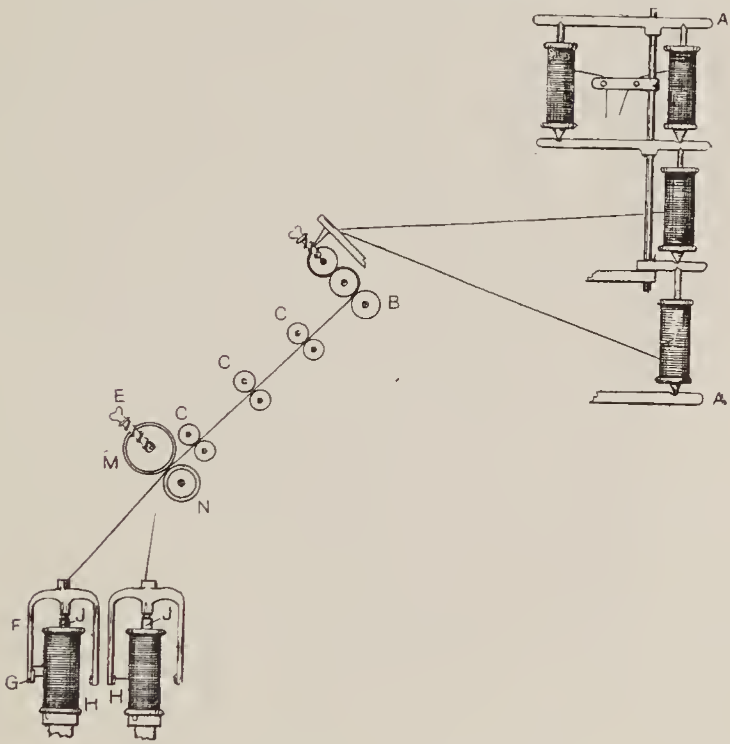


FIG. 85.—Dandy rover (side elevation).

Dandy roving frame.—Hitherto all the drawing has been done by means of rollers and fallers, but the dandy roving frame has no screws or fallers, the drafting being done by rollers only, and the draft being direct from the front rollers to the back rollers. The frames are made with forty or more spindles, and are arranged as shown in

Fig. 85, which is a side elevation, and Fig. 86, which illustrates an 80 spindle cone roving frame. Two or three bobbins—the number again depending on the thickness of the roving and the count it is desired to spin—from the

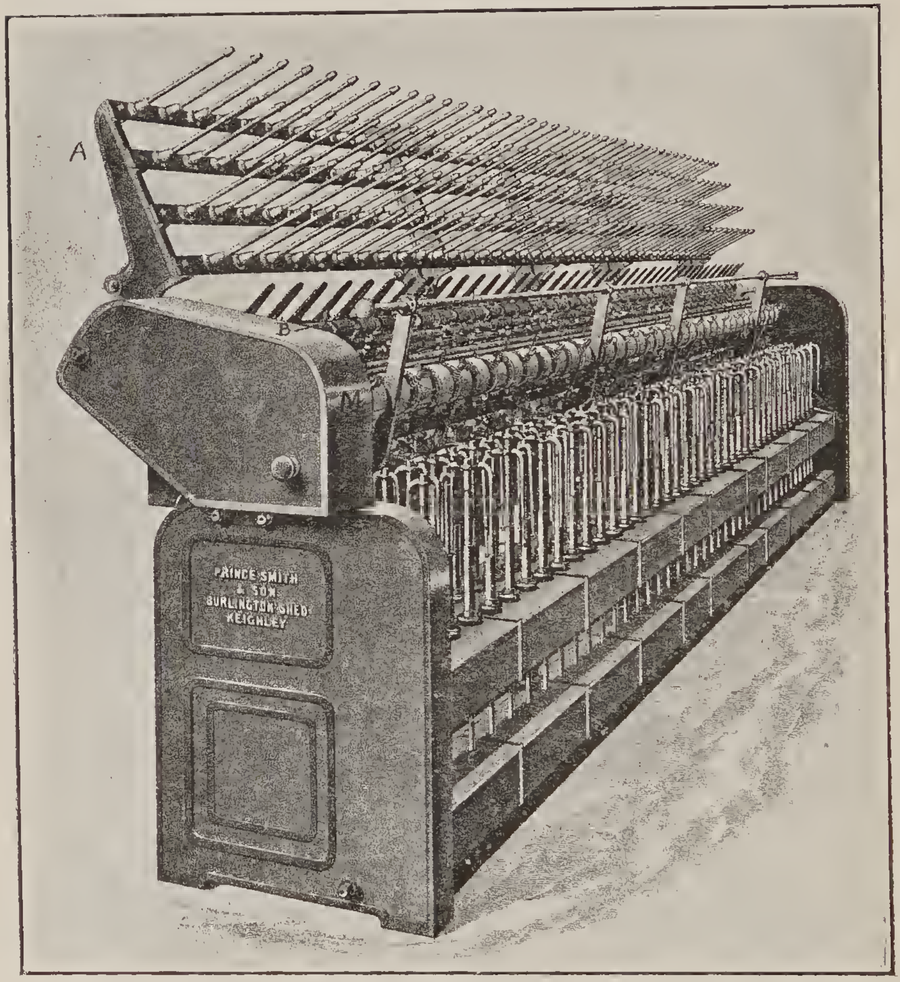


Fig. 86.—80 spindle cone rover.

slubbing frame are put up behind each spindle in creels A. Each end is guided separately into the back rollers B, and thence to the front rollers M, N. The three rows of small rollers C are called carrier rollers, and are revolved at a proportionate speed to the back rollers B, thus acting as carriers or supports of the roving from the back to the front rollers. The back rollers revolve slowly, and the front rollers quickly, thus drawing out the rovings into a thinner size or count. The bottom front roller N is the one which affects the draft, the top one being only a wooden boss covered with leather or rubber, and running on the bottom roller by friction, every pair on their own axis and pressed down by screws E. When the attenuated end is delivered in front of the rollers, it is twisted round the ring of the flyer F, passed through the twizzle G, and thence to the bobbin H on the spindle J. These machines are almost all made with cone driving, so that the roving can be wound on the bobbin with a soft twist without fear of stretching the roving between the nip of rollers and the flyer. The rovings are known as 4-hank, 8-hank, 10-hank, etc., a 4-hank being 4 hanks of 840 yds. each to the pound, and a 10-hank equalling 10 hanks of 840 yds. each to the pound, and so on.

Having now described the principles of all the preparing machines previous to passing on to the spinning frame for long fibres—*i.e.* first and second drafts—it is necessary to go through the preparatory machinery to show the changes necessary for shorter drafts or fibres of silk.

Drawing short silks—Intersecting—Spreading.—In drawing machinery such as spreaders, sett frames, and drawing boxes, what are known as intersectors, or intersecting fallers, are used for the third and fourth drafts. In order, also, to be able to place the drawing rollers as near to the fallers as possible, so that the nip of the rollers may have hold of the shorter fibres before they emerge entirely from the fallers, the rollers are smaller in diameter for short silk than for long, and the same remark applies to the back roller or porcupine. Fig. 87 shows the principle of the intersecting fallers, where A is the feed plate, B the feed rollers, C the porcupine, with three small iron rollers D to keep the silk firm on the pins of the porcupine; E are the fallers which *rise* into the silk, F are the fallers which *drop* into the silk, while G are the drafting rollers which feed the rollers H and J described in Fig. 81.

These machines are designed to ensure the silk being properly drawn, for as the fibre is short the silk is inclined to be loose and fluffy, and it is difficult to make the faller pins rise and pierce through it. If the slivers ride on the top of the pins to the front rollers, the rollers simply pull the silk off the top of the pin the same thickness as fed to the back of the fallers, thus making a bad place; or, in some cases a large portion of the silk is in the pins and a small portion on the top, and therefore some is drawn and

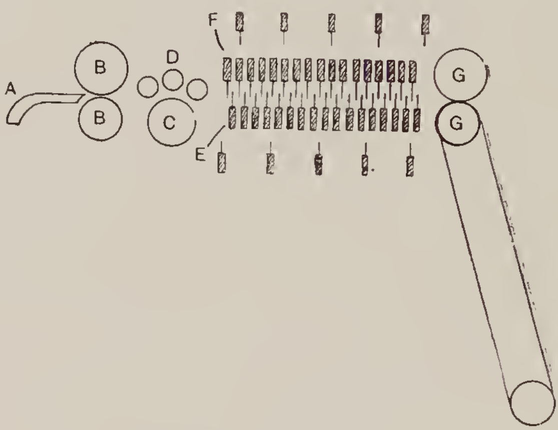


FIG. 87.—Intersector.

some not drawn, with the result that if the finished sliver is held up to the light it looks thick and thin, as shown at B in Fig. 88, the sliver at A—one properly drawn—being given for comparison. By using the two sets of fallers, one with pins pointing down and dropping into the silk, and the other rising into it, it is almost impossible for any silk to miss being drafted. These frames require even greater attention than the ordinary gill drawing frames, because they contain the complicated mechanism necessary to give motion to the upper fallers, which must work extremely accurately to prevent locking and breaking. The silk also must be put in thinner and worked more slowly in these machines. The machinery for short drafts would be set out as follows: Intersecting spreader, intersecting re-lapper, sett frame, and 3 or 4 heads of drawing with 8 or 10 ends of sliver up behind each head. From there the sliver would go to a gill rover, and thence to the dandy frame.

The speed of the fallers for long silk is about 300 drops per minute, for short silk about 150 to 200 drops per minute.

The draft of long silk is from 15 and upwards in spreading, from 6 and upwards in the other drawing, machinery; while for short silk it is, in spreading, from 10 and upwards, and in drawing frames from 6 and upwards.

The best yarns are produced by having the drafts nearly

Fig. 88.—Slivers.

equal in each machine. The *draft* should, of course, be less for short silk than for long, but the *twist* in slubbing and drawing must be more for short silk than long-fibred silk.

Care should be taken with all silks, and under all systems of drawing, that the drafting is not done twice the same way. Carelessness in this has caused much trouble to spinning overlookers and managers, and spoilt much yarn. Drafting twice the same way means that a sliver has been put twice in succession through a drawing operation with the same end first, and this causes the end to be thick and thin, and to work badly in the succeeding operation. The reason for this trouble would appear to be best illustrated as follows: The three lines in Fig. 89 represent three slivers, say of 10 yds. in length, which are drawn out end A first, with 12 of a draft, into 120 yds. of sliver. If this is put up again end A first, and again with 12 of a draft, 1440 yds. of silver, or 144 times the length of the original 10 yds., will be obtained. This is obviously too much of a pull in one direction, and it would be practically impossible to get the silk to run. But if in the second box or drawing the end B is put up first, then the fibres which were drafted one way (arrow C) in the first box, are pulled or drafted the other way (arrow D) in the second box, having thus moved relatively to each other first forwards and then backwards, 12 of a draft each way instead of 144 one way.

It is the moving back of the fibres in each drawing operation that helps to keep the slivers and rovings free from thick and thin places, and these remarks apply to all drafting operations, from sett frame to dandy roving frame

Fig. 89.—Drafting.

inclusive. Therefore overlookers should insist that all drawing frame, gill roving frame, and dandy frame attendants do not, while following their respective occupations, upset cans of sliver or re-wind part bobbins of rovings without, in the case of slivers, seeing that the right end is found, and, in case of rovings, that they are wound twice before being passed on to the next machine.

Rotary drawing.—For very short drafts—*i.e.* fourth to sixth—the rotary-drawing principle is good. The drafts are spread very thinly on intersector spreading boxes, re-spread twice, made into a sliver on an intersector sett frame, and then drawn by means of a rotary drawing frame like that illustrated in Fig. 90 in sectional side elevation, and in Fig. 91. This latter is a photograph of two heads of drawing, each with two deliveries. Six or more cans A of sliver B from the sett frame are placed behind the first drawing head and conveyed into the back retaining rollers C, thence under the porcupine D, and over the porcupines

E and F, being held on the pins of the two latter by means of a small metal roller G. The front drawing rollers F draw the silk through the pins of the porcupines, delivering it on to the leather drawing sheet J, which in its turn

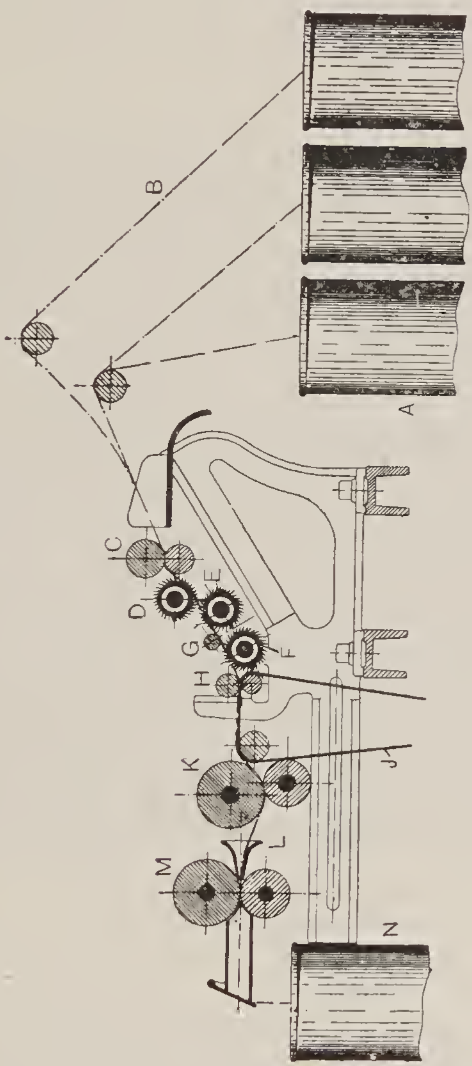


Fig. 90.—Rotary drawing frame (section).

conveys it to the pressing rollers K and delivery rollers M, when it drops into the can N. It is well to have the funnel L made to revolve, in this way putting a false twist into the sliver. This false twist helps to solidify the sliver, preventing it from "flying" so much, thus obviating waste.

It is necessary to use from two to four heads of drawing, the number depending entirely on the character of the spreading and respreading. Usually four heads are needed to make a level sliver. The drafting of the silk is between the front and back rollers, and the porcupines serve as carriers for supporting the silk, and also act as endless fallers. The pins pierce the sliver and hold it steady

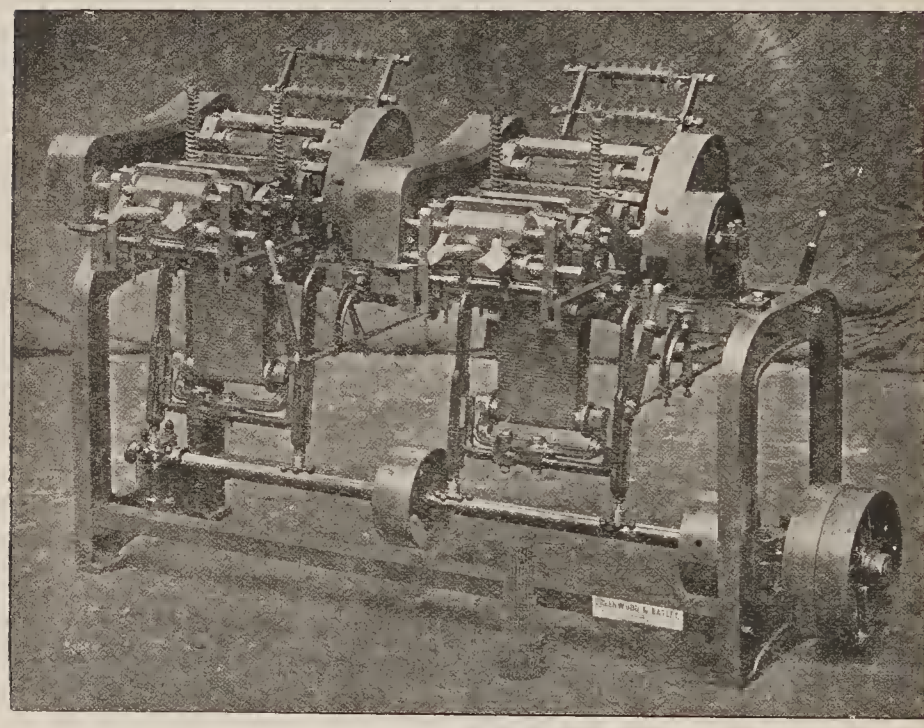


FIG. 91.—Rotary drawing frame.

whilst the front rollers draw it. The top of front porcupine F must be kept higher than the nip of the front rollers, thus bringing the nip of the rollers and the point where the silk leaves the pins near together to prevent short silk missing drawing.

Rotary roving frame.—After drawing, the silk is taken from the finisher head to the rotary roving frame, shown in Fig 92 in sectional side elevation. Two or more ends are drawn together, travelling from the cans A, over the feed-plate B, to the back rollers C, under and over porcupines D, E, F to the front drawing rollers G, and then wound by the flyer H on to the bobbin J. The twist is kept fairly soft, so that the next machine—the roving frame—can draw easily. A roving frame for short silk works on the same principle as the one illustrated in Fig. 85; but only two sets of carrier rollers are needed, and the rollers are all small in diameter.

Dimensions of drawing machinery.—The following tables of dimensions of the machinery described for drawing silk will be found useful (see pp. 160 and 161).

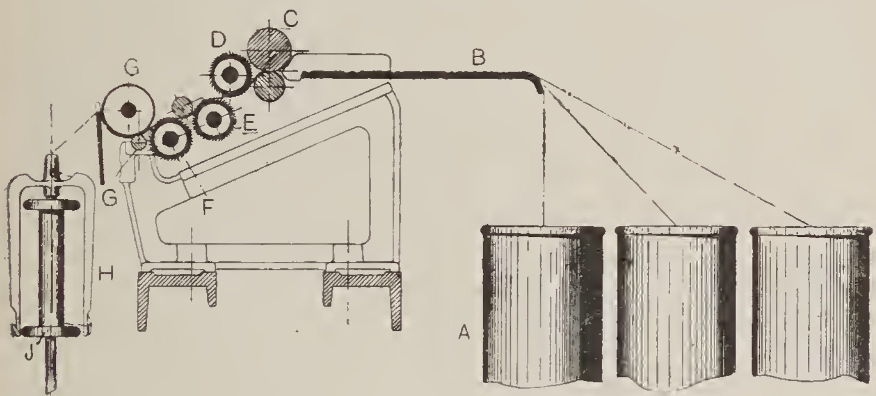


FIG. 92.—Rotary roving frame.

Rotary drawing frame.—Three porcupines per head. Pins set 20 to 22 per inch. Back rollers: bottom, $1\frac{1}{2}$ in. diameter; pressing or top, 2 in. diameter. Front rollers: bottom, 1 in. diameter, 10 flutes; top, $1\frac{1}{2}$ in. diameter, 15 flutes. Delivery rollers: bottom, $2\frac{1}{2}$ in. diameter; top, $3\frac{1}{2}$ in. diameter. The drafts are from 4 to 9, and the space occupied is 12 ft. 6 in. by 3 ft. 6 in. for four heads.

Rotary roving frame.—Three porcupines per spindle. Back roller, $1\frac{1}{2}$ in. diameter; front roller, $\frac{13}{16}$ in. diameter, 32 flutes; top front roller, $2\frac{5}{8}$ in. diameter. The top front roller is covered with indiarubber or leather. The length of reach from the back to the front rollers is $7\frac{1}{2}$ in., the drafts are from 4 to 10, and the twist from $\frac{1}{2}$ to 2 per inch.

OPEN GILL DRAWING FOR LONG OR MEDIUM DRAFTS.

	Spreader and Respreader.		Sett Frame.	Drawing Frames.				Slubbing Roving Frame.
	Long Drafts.	Short Drafts.		First Head.	Second Head.	Third Head.	Fourth Head.	
Fallers up	$7\frac{1}{4}$ in.	$5\frac{1}{4}$ in.	$7\frac{1}{4}$ in.	$7\frac{1}{4}$ in.	$7\frac{1}{4}$ in.	$7\frac{1}{4}$ in.	$7\frac{1}{4}$ in.	$7\frac{1}{4}$ in.
Screws cut per inch	4	4	4	5	5	5	5	5
Pins per faller per inch	16	16	16	18	20	22	24	28
Length of pin	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.	$\frac{11}{16}$ in.
Set over	$9\frac{1}{8}$ in.	$9\frac{1}{8}$ in.	$9\frac{1}{8}$ in.	8 in.	8 in.	8 in.	8 in.	1 in.
Retaining rollers diameter[1]	2 in.	2 in.	2 in.	$1\frac{1}{2}$ in.	$1\frac{1}{2}$ in.	$1\frac{1}{2}$ in.	$1\frac{1}{2}$ in.	$1\frac{1}{2}$ in.
Feed-sheet rollers diameter	$2\frac{1}{4}$ in.	$2\frac{1}{4}$ in.	$2\frac{1}{4}$ in.	...	...	...	...	...
Pressing rollers weighted by	Spiral springs.		Spiral springs.	...	...	...	...	...
Front drawing rollers diameter	$1\frac{3}{4}$ in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	1 in.	1 in.	1 in.	1 in.	1 in.
Number of flutes	14	10	12	10	10	10	10	42
Front pressing rollers diameter	$2\frac{1}{2}$ in.	2 in.	$2\frac{1}{4}$ in.	1·7 in.	1·7 in.	1·7 in.	1·7 in.	$2\frac{3}{4}$ in.
Number of flutes	20	16	18	17	17	17	17	...
Front pressing rollers weighted by	Spiral springs.		Spiral springs.	Spiral springs each head.				...
Delivery rollers diameter	...	...	3 in.	$2\frac{1}{2}$ in.	$2\frac{1}{2}$ in.	$2\frac{1}{2}$ in.	$2\frac{1}{2}$ in.	...
Pressing rollers diameter	...	...	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.	...
Drum diameter	3 ft.	2 ft.	...	...	...	...	...	...
Drum width	12 in.	12 in.	...	...	...	...	...	...
Drafts	15 to 30	10 to 24	10 to 20	6 to 14	6 to 14	6 to 14	6 to 14	6 to 14
Delivery per head	...	...	1	1	1	1	1 or 2	...
Space occupied	8 ft. 6 in. × 3 ft. 10 in.	...	7 ft. 2 in. × 3 ft. 10 in.	13 ft. 6 in. × 3 ft. 6 in.				20 ft. 2 in. × 3 ft.

[1] Open gill spreaders are often made with porcupine rollers behind the fallers to retain the silk.

INTERSECTING GILL DRAWING FOR LONG AND MEDIUM AND SHORT DRAFTS.

	Spreader and Respreader.		Sett Frame.		Drawing Frames.							
					First Head.		Second Head.		Third Head.		Fourth Head.	
	Long Drafts.	Short Drafts.	Long Drafts.	Short Drafts.	Long Drafts.	Short Drafts.	Long Drafts.	Short Drafts.	Long Drafts.	Short Drafts.	Long Drafts.	Short Drafts.
Fallers up	8 in.	5 in.	8 in.	5 in.	7½ in.	5 in.	7½ in.	5 in.	7½ in.	5 in.	7½ in.	5 in.
Screws cut per inch	3	3½	3	3½	3½	4	3½	4	3½	4	3½	4
Pins per faller per inch	14	16	16	16	18	18	20	20	22	22	24	24
Length of pin	1 in.	1⅝ in.	1 in.	1⅝ in.	1 in.	1⅝ in.	1 in.	1⅝ in.	1 in.	1⅝ in.	1 in.	1⅝ in.
Set over	9⅛ in.	9⅛ in.	9⅛ in.	9⅛ in.	8 in.	8 in.	8 in.	8 in.	8 in.	8 in.	8 in.	8 in.
Retaining rollers diameter	...	...	...	...	1½ in.	1½ in.	1½ in.	1½ in.	1½ in.	1½ in.	1½ in.	1½ in.
Feed-sheet rollers diameter	1½ in.	1½ in.	1½ in.	1½ in.	...	...	...	...	...	...	...	...
Feed-sheet rollers number of flutes	15 each.	15 each.	15 each.	15 each.	...	...	...	...	...	...	...	...
Front drawing roller dia.	1½ in.	1¼ in.	1½ in.	1¼ in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.	1 in.
Number of flutes	12	10	12	10	10	10	10	10	10	10	10	10
Front pressing roller dia.	2 in.	1¾ in.	2 in.	1¾ in.	1·7 in.	1½ in.	1·7 in.	1½ in.	1·7 in.	1½ in.	1·7 in.	1½ in.
Number of flutes	16	14	16	14	17	15	17	15	17	15	17	15
Front pressing weighted by	Springs.	Springs.	...	Springs.	Springs.	Springs.	Springs.	Springs.	Springs.	Springs.	Springs.	Springs.
Delivery rollers diameter	...	..	3 in.	3 in.	2½ in.	2½ in.	2½ in.	2½ in.	2½ in.	2½ in.	2½ in.	2½ in.
Pressing rollers diameter	...	...	3½ in.	3½ in.	3½ in.	3½ in.	3½ in.	3½ in.	3½ in.	3½ in.	3½ in.	3½ in.
Drum diameter	3 ft.	2 ft.	...	...	...	...	...	...	...	...	...	...
Drum width	12 in.	12 in.	...	...	...	...	...	...	...	...	...	...
Drafts	15 to 30	10 to 24	10 to 20	6 to 18	6 to 14	6 to 14	6 to 14	6 to 14	6 to 14	6 to 14	6 to 14	6 to 14
Delivery per head	...	...	1	1	1	1	1	1	1	1	1 or 2	2
Space occupied	8 ft. 6 in. × 3 ft. 10 in.	7 ft. 6 in. × 3 ft. 10 in.	7 ft. 2 in. × 3 ft. 10 in.	7 ft. 2 in. × 3 ft. 10 in.	13 ft. 6 in. × 3 ft. 6 in. for both long and short.							

There is a double-cone regulating motion, single row of spindles, $4\frac{1}{4}$ in. pitch, for 6 by 3 in. bobbins, and the space occupied is 17 ft. 6 in. by 3 ft.

The screw gill roving frames are made with double-cone regulating motion, a single row of spindles, four spindles per head, for 6 by 3 in. bobbins. The front pressing roller is covered with indiarubber or hard leather. The sliver guides on the back apron are $\frac{3}{8}$ in. wide, behind the gills are $\frac{1}{4}$ in. wide, and twists vary from $\frac{1}{2}$ to 2 turns per inch. The frames illustrated are arranged with special gearing changes to run the fallers at a uniform speed whatever the draft or twist may be.

The dimensions of a dandy roving frame are: For medium lengths or drafts: back rollers, $1\frac{1}{2}$ in. diameter; two lines carrier rollers, 1 in. diameter; and one line carrier rollers nearest the front rollers, $\frac{3}{4}$ in. diameter. The front roller is 2 in. diameter, 36 flutes per inch, and the front pressing roller is $2\frac{1}{2}$ in. diameter, covered with indiarubber or leather and weighted by springs or lever and weight. The length of the reach is from 7 to 12 in. The creel is made to carry 4 roving bobbins per spindle, the drafts are from 4 to 12, twists vary from 1 to 4 turns per inch, the space occupied is 25 by 3 ft., the lift is 6 in., and the bobbins are 6 by 3 in.

For long drafts the back rollers are 2 in. diameter, the carrier rollers nearest the back rollers are $1\frac{1}{8}$ and 1 in. respectively, the carrier rollers nearest the front rollers are $\frac{7}{8}$ and $\frac{3}{4}$ in. respectively, the front rollers are 3 in., the front pressing rollers 4 in., and the spindles about $\frac{5}{8}$ in. diameter.

CHAPTER IX.

SHORT SPINNING MACHINERY.

Spreading short fibres of silk on gill spreading machinery is not the best mode of dealing with shorts when levelness of thread irrespective of lustre is required. The fibres, being so irregular in length, are difficult to draw level, and therefore shorts are often carded and put over machinery similar to that used in spinning fine cotton. The cards, however, dull the lustre of silk, and in time it is quite probable that the processes called short spinning will be

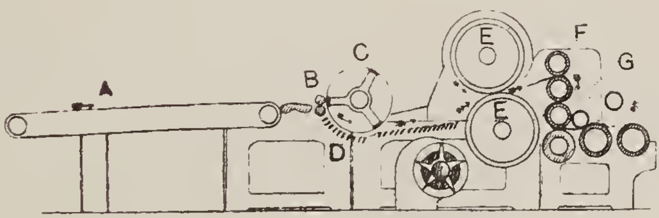


Fig. 93.—Scutching.

discontinued in favour of gill machinery. Many books have been written on the mechanism of fine-cotton spinning machinery; it is only necessary here to briefly glance at the processes.

Mixing.—The shorts, of various qualities and shades of colour, are made into a mixing and stacked in a cool cellar for some days before use, in order to condition. They are then scutched by means of the machine illustrated in Fig. 93.

Scutching.—The silk is placed evenly on lattice feeder A, which carries it to the rollers B. These deliver it to the action of the beaters C, which, revolving quickly, beat the silk against the grid bars D, thus cleaning the silk from dust and other impurities, the dust, etc., falling through the grid on to the floor of the machine. The

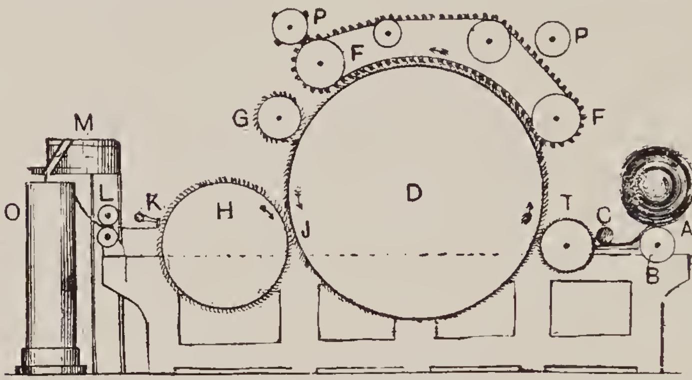


FIG. 94.—Flat card (section).

silk is carried forward in a loose fluffy state to the cages E, passing then to the calender rollers F (in the direction shown by the arrows), and is made into a lap G.

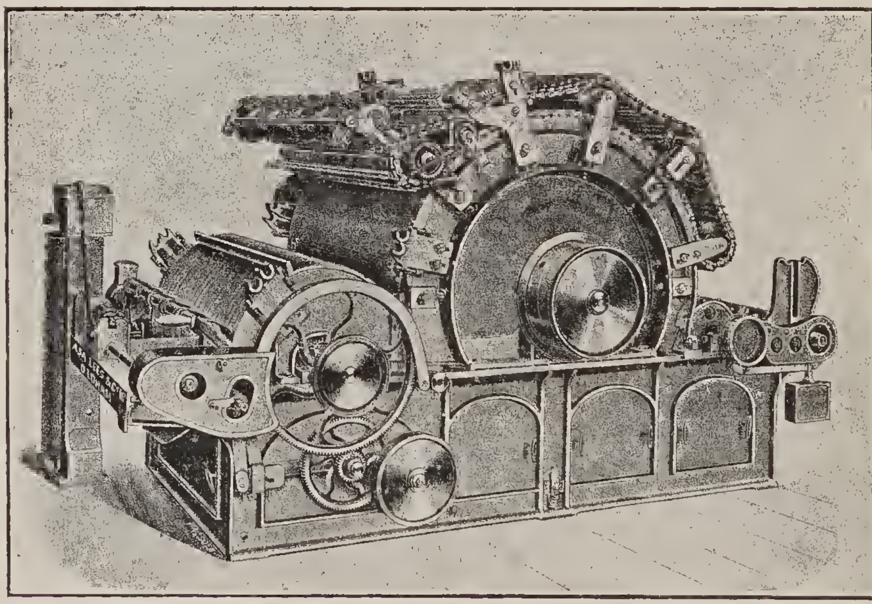


FIG. 95.—Flat card.

Carding.—When complete the lap is taken to the card (Figs. 94 and 95) and placed at A, where it is unwound by the revolution of the roller B, assisted by the feed roller C, which delivers the fleece of silk to the taker-in T. This taker-in being covered with coarse wire, pierces the silk, and carries it forward to the cylinder D, which is the main carding cylinder. The teeth of the carding cylinder sweep the silk off the taker-in and carry it forward to the carding flats F. The teeth on these flats are set to face those of the main cylinder D, and travel forward in the same direction as the surface of the cylinder, but at a slower speed. The silk is thus carried against the teeth of the flats, and sustains a thorough opening and carding. After the action of the flats, the silk is slightly raised out of the teeth of the main cylinder by the action of the fancy card G, thus assisting the action of doffer cylinder H, which takes off the fleece of silk from the cylinder D. The doffer works at a much slower speed than the main cylinder, and by this further straightens and stretches the fibres as they leave the pin points at J, whence they are carried on the underside of the doffer to the vibrating comb K, which describes a short arc of $1\frac{1}{4}$ in. vertical movement. This comb strips the fibres from the face of the doffer on its down-stroke and clears itself on its up-stroke. The thin fleece, almost the width of the doffer, is gathered to a width of 6 or 7 in. and placed into a funnel, through the narrow end of which it is drawn by the calender rollers L, carried upwards in the form of a ribbon or sliver to the coiler M, and coiled into the can O. The flats are stripped of their impurities by a brush and comb at P, and the wires are always kept sharp by the grinding roller at R.

Drawing.—From the cards the slivers are taken to the drawing frame (Figs. 96 and 97). Six or eight of the slivers are drawn from the cans A, and pass over the tumblers B of the back stop motion to the back rollers C, through the carrier rollers D and E, to the front drawing rollers F, into the coiler G and the can H. Various automatic contrivances, electrical and mechanical, are arranged to stop the machine when a sliver breaks behind the machine or in front, or when the can H is full of sliver. The silk is drawn through three or four heads of drawing

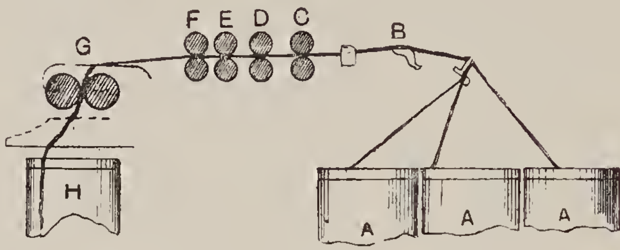


FIG. 96.—Drawing head (section).

frames, with a draft varying from 3 to 8, usually drafting in accordance with the number of ends up—*i.e.*, three ends up would have a draft of 3, and eight ends up a draft of 8.

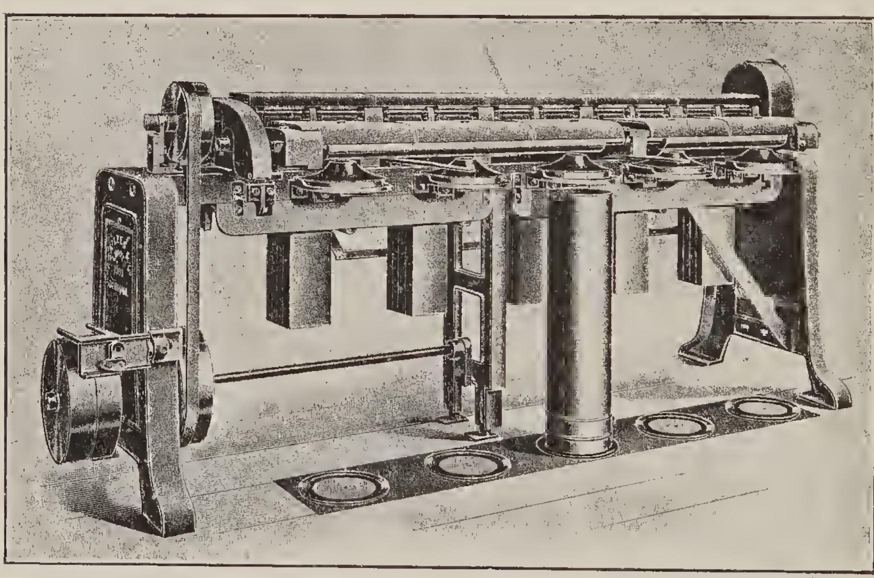


FIG. 97.—Improved drawing frame.

Slubbing and fine frames.—These are used in accordance with the fineness of the roving required, and are for the purpose of still further elongating and stretching the fibres, while in these frames the silk receives twist, but never in the drawing. For coarse counts of yarn it is usual to put the drawing slivers over a slubbing frame only; for medium counts, over slubbing and intermediate frames; and for very fine counts, over slubbing, intermediate, and fine roving frames. The slubbing frame receives the sliver in at the back rollers, passes it through the carrier rollers to the front drawing rollers, and thence on to the spindle and flyer, which wind it on to a large tube. The intermediate and fine frames are built in the same style, but are made to receive bobbins instead of slivers behind. These frames are illustrated in Fig. 98, where A is the slubbing bobbin, two or three of which are placed behind each spindle.

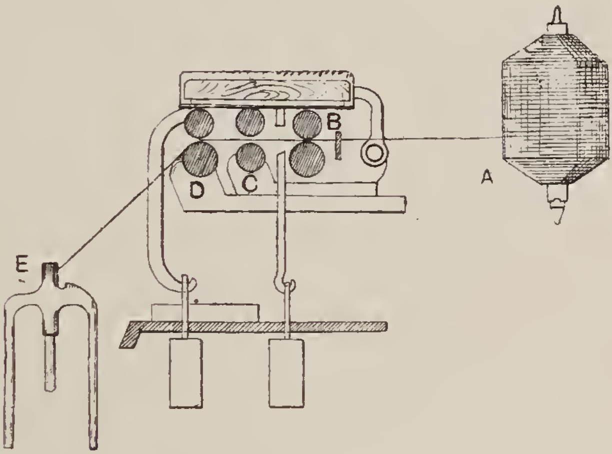


FIG. 98.—Slubbing frame.

The ends are guided to the back rollers B, through the carrier rollers C, to the front drawing rollers D, which deliver to spindle and flyer E, eventually winding on to a bobbin or tube.

Silk cannot be carded at the same speed and in the same weight as cotton. It is more apt to nib and gather electricity, and if too great a speed is attempted a large amount of waste is caused by the fibres flying. A moderate speed will give the best results, and if the cylinder runs at about 90 revolutions per minute, the doffer will only need to run at about 6 revolutions per minute. The production per card per week is from 200 lb. to 250 lb. with such speeds.

The drawing frame rollers are about $1\frac{1}{4}$ in. diameter. Some spinners card the short fibres on the breaker and finisher card system and then continue drawing operations through the open drawing frames described, or through the rotary gill drawing frames. The latter system gives a clean, level, and lustrous thread.

CHAPTER X.

SPINNING AND FINISHING PROCESSES.

Fly spinning.—All classes of silk, long or short, can be spun on mules, ring frames, cap frames, or flyer frames, if the drafting rollers are made suitable, a long strong silk needing a large diameter, and a short weak silk a small

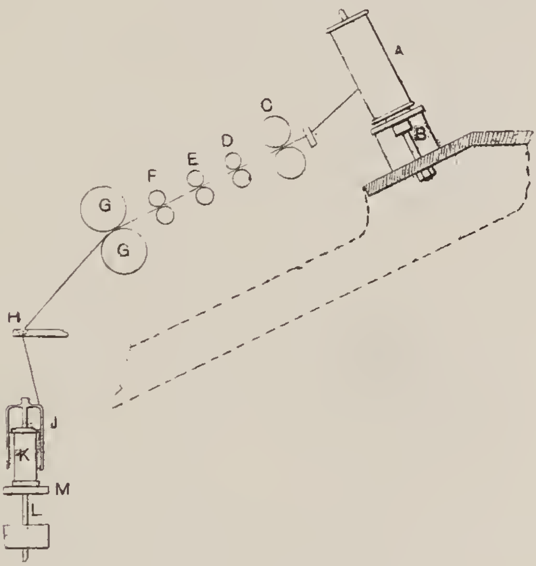


FIG. 99.—Flyer spinning frame.

diameter of roller. A silk of irregular length is best spun on a medium diameter of roller. At one period all long-spun yarns were spun on flyer frames and short-spun silks on mules, but ring and cap frames are now largely adopted. Fig. 99 illustrates the principle of flyer spinning, and Fig. 100 shows the machine in work. The roving bobbin A is placed on the peg B, one bobbin to each spindle. The end is passed between the back rollers C (which revolve slowly), then

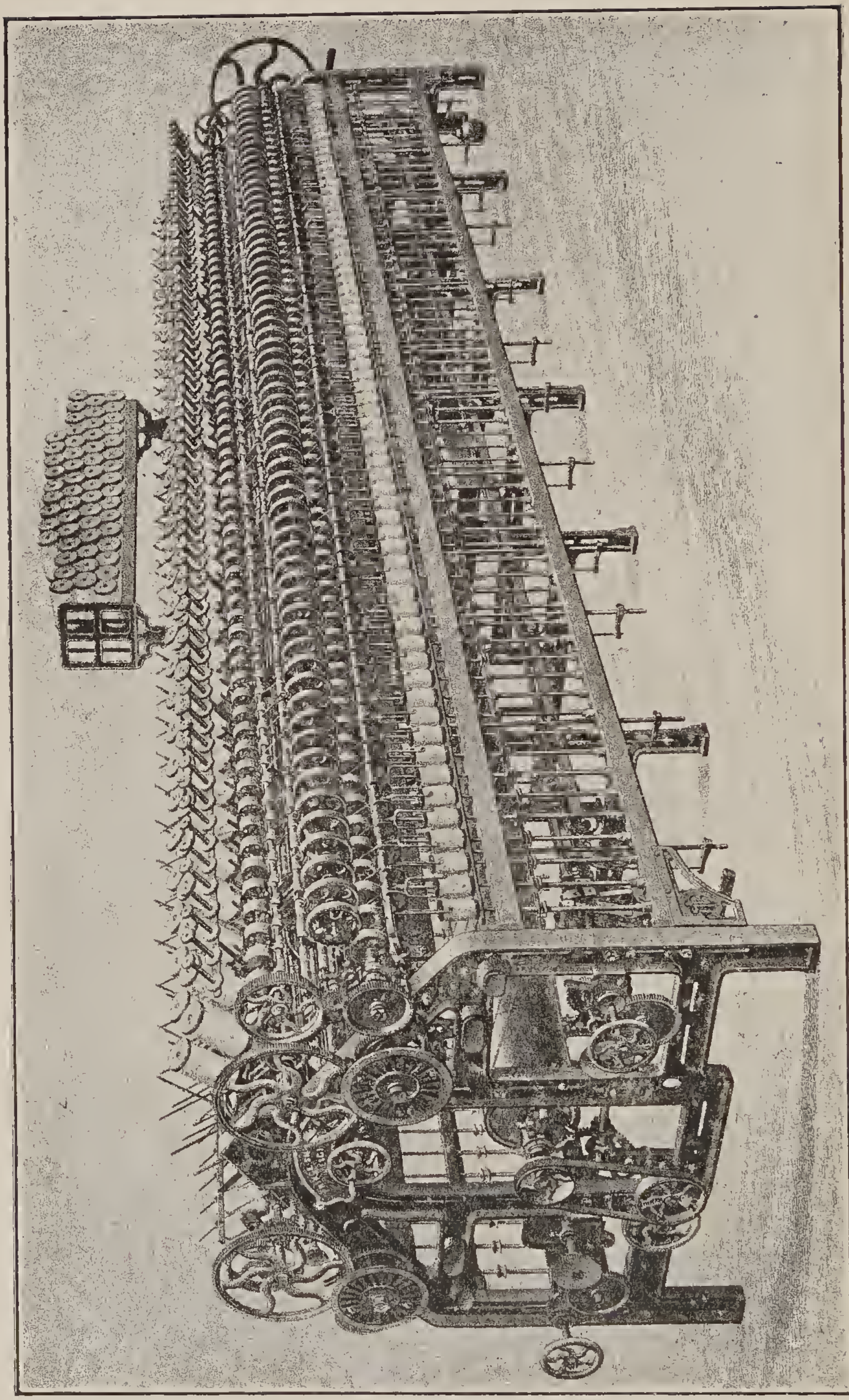


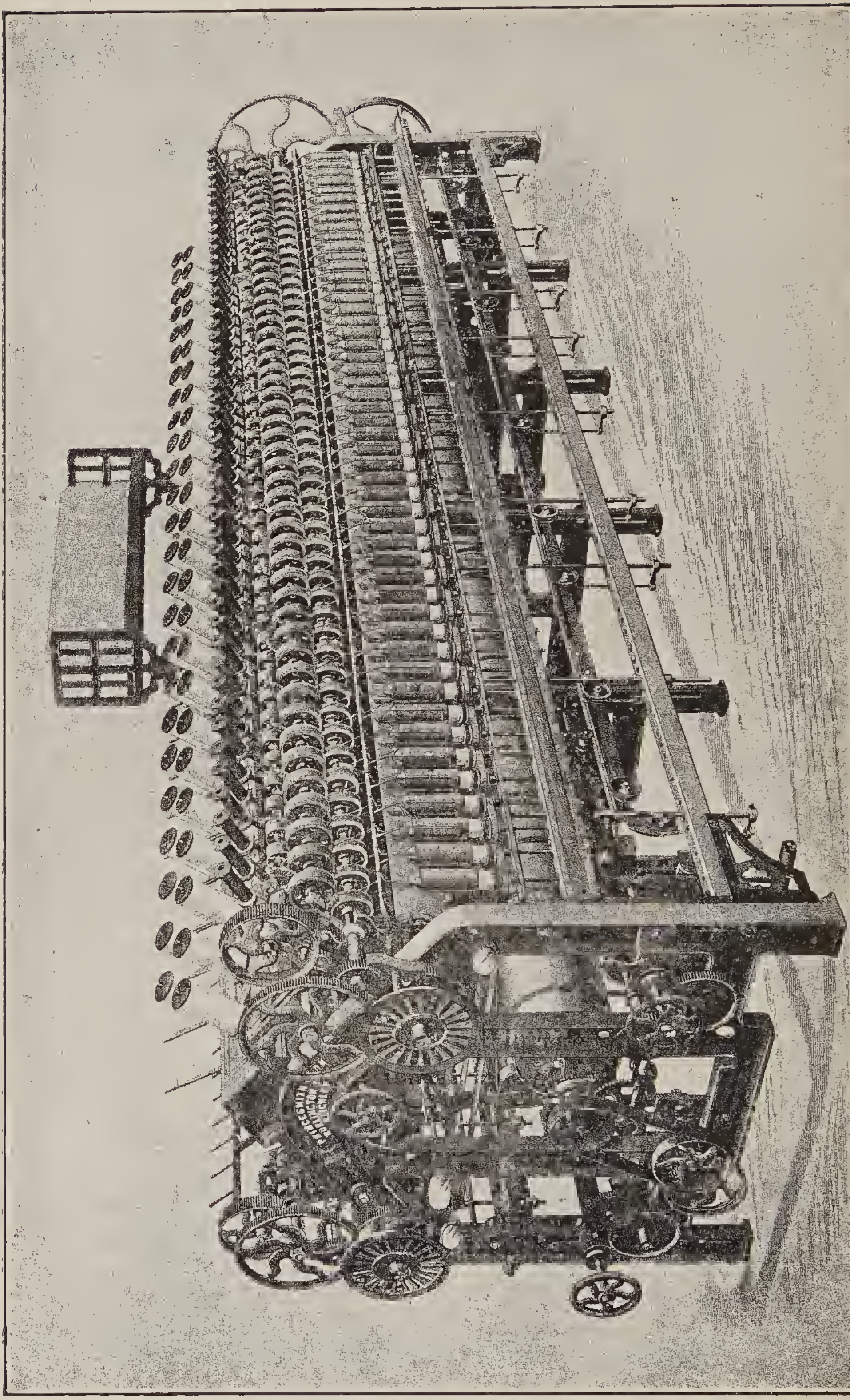
FIG. 100.—Flyer spinning frame.

between the three sets of carriers D, E, F, and reaching the front rollers G, is drawn out to the length required, the difference in the speed of the back and front rollers regulating the draft. When the attenuated end comes through the front roller it is conveyed through the top board H, wrapped round the leg of the flyer J, passed through the twizzle at its lower end, and then wound round the bobbin K on the spindle L. The bobbin travels up and down the spindle on the lifter plate M, thus allowing the silk thread to be wound evenly by means of the flyer.

Besides winding the thread on to the bobbin, the flyer puts twist into the thread by its revolution round the bobbin, one turn of twist for each revolution. If the bobbin and flyer travelled at the same speed the thread would have twist put in, but would not be wound on the bobbin; but the bobbin being loose on its spindle, its tendency is to remain stationary, and it is therefore "dragged" around by the thread. The number of turns per inch is regulated by the number of revolutions of the flyer and the speed of delivery of the front rollers. If these are 4 in. diameter the circumference will be 12·5, and whilst revolving at 40 revolutions per minute will deliver 500 in. of yarn per minute. The spindle revolves at 6000 revolutions per minute, and therefore 6000 ÷ 500 gives 12 turns per inch.

In a flyer frame the bobbin runs quicker the fuller it gets, and therefore it is awkward to regulate the drag so that the end does not break. Between the bobbin bottom and the lifter plate, paper, leather, or cloth washers are placed to regulate the friction. If the bobbin does not drag enough, the thread snarls before being wound on the bobbin, and if it drags too hard the thread breaks. The spin is always worst in a fine count when the bobbin is full, because the thread is pulled in two by the drag; and worse in a coarse count, when the bobbin is empty, because the drag is so little that the thread snarls.

Cap spinning.—A cap frame (Fig. 101) can be run at



a higher speed than a flyer frame, and this higher speed makes a slightly rougher yarn. The difference between cap and flyer is in the spindles and caps, which are stationary. The cap is a steel cap-shaped shell placed on the spindle, having its inside measurement of larger diameter than the bobbin head, so that it admits the bobbin when it is full of yarn. The rotary portion is a tube fitting inside the bobbin, on the spindle, and revolved by a whorl. To put twist into the thread, instead of the flyer revolving round the bobbin, the cap bobbin revolvesround the spindle. The cap forms a smooth surface, round which the thread revolves without much friction, and the bottom rim guides the thread on to the bobbin. The extra speed of a cap over a flyer frame makes it possible to produce a cheaper yarn, and as silk is spun to fine and costly counts, cap frames are superseding flyer frames very rapidly.

Ring spinning.—A ring-spinning frame is most useful for short-fibred silks, because of the possibility of regulating the tension on the thread by means of the different sizes of travellers. Cap-spinning frames are run up to 9000 revolutions per minute. For long-fibred silks the drawing rollers are 4 in. diameter, medium fibres need 3 or 3½ in. diameter, and short silks 1½ to 2½ in. diameter. Mule spinning is not liked, because the rotatory action exerted on the thread when "on the stretch" loosens the fibre, and so dulls the lustre, besides causing more loss to take place in the later processes of gassing and cleaning.

Winding.—After spinning, the yarn is ready for folding into two-fold or three-fold yarn. In many cases it is wound before folding. Winding (Fig. 102) consists of running one or more spun threads from the spinning bobbin on to a bobbin of large diameter. If only one thread is wound on to one bobbin, the only object in the winding is to ensure less doffing and creeling in the twisting frame. When two or more ends are wound on to one bobbin, the above-named object is one reason for the winding, and a further reason is to ensure that the folded and finished yarn contains the requisite two or three threads throughout the whole of its length. Therefore a winding machine is fitted

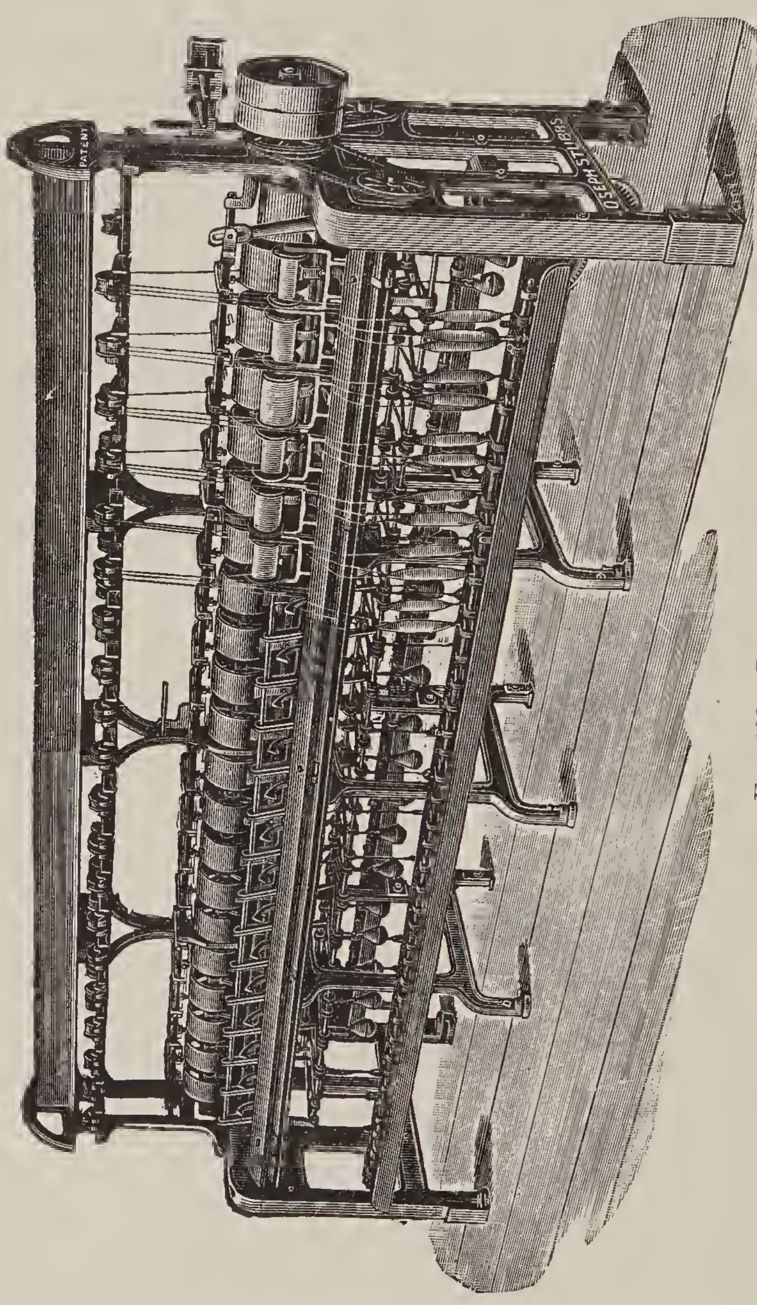


FIG. 102.—Doubler winder.

up with stop motions, so that when any thread breaks, the receiving bobbin ceases to revolve until the attendant ties up the thread again. Many spinners consider that winding three threads for sewing cords, before twisting, makes a more even thread, inasmuch as proper tension can be put on each single thread, so preventing one strand riding on the others, which fault causes a weak place, besides an unsightly thread.

Copping.—Another class of winding is required when the single thread is used for weft. The yarn is then only spun with a very soft twist, and usually wound straight from the spinning bobbin on to a long paper tube by any of the usual cop or pirn winding machines. If a short spun weft is required, and the spinner happens to spin on mules, then the yarn can be sold on the paper tubes on which the yarn was spun, and rewinding saved.

Twisting.—A twisting frame is practically a spinning frame without back rollers or carriers, and therefore without draft. It consists of rollers to draw the yarn from the spinning or wound bobbins, and these same rollers deliver the yarn to the spindles for the purpose of having twist put in the thread. The twist is reckoned and put in the yarn exactly in the same manner as in spinning, only twisted in the opposite direction to the spinning twist. The effect of twisting is to untwist the single yarn whilst twisting a two- or three-fold thread, and this fact should be borne in mind if a hard-twist yarn is required. The yarn should be twisted hard in the spinning, for the more twist put in the folded thread the less remains in the single thread. Yarn loses a little length in twisting proportionate to its thickness and the amount of twist, the loss of shrinkage thus varying with every count and degree of twist.

If yarns are twisted after winding, the simplest form of machine can be used, as illustrated in Fig. 103, which is a ring doubling or twisting frame. A is the bobbin on to which two strands (two single threads) have been wound, B the thread travelling in the direction of the arrows to and around rollers C and D, thence to the ring and spindle E, the latter of which is propelled by the whorl G driven by the cylinder H. If the yarn is not wound before twisting, it is usual to use a machine which has an automatic arrangement for stopping the spindle whenever the single thread breaks behind the rollers or the folded strand in front breaks or snarls.

Twisting frames are made with cap, fly, or ring spindles. A flyer frame is best for very coarse, heavy, and hard-twisted yarns, but silk being usually spun into fine counts,

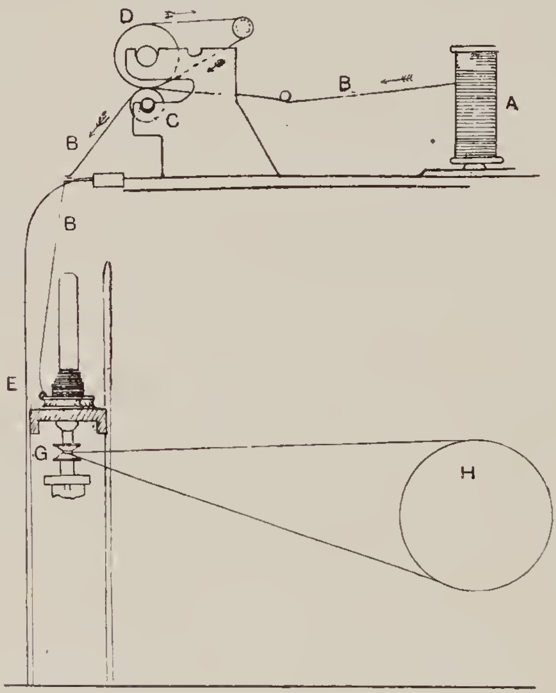


FIG. 103.—Ring twisting frame.

the ring doubling or twisting frame is very largely used on account of the speed at which these machines can be run. When ring frames are used it is important to have perfectly true and upright spindles, and to see that the ring is true and smooth, and the spindle set exactly in the centre of the ring. The travellers must be kept in good order, and the thread guides set exactly over the top of the spindle so that the yarn makes a perfect cone when revolving.

Cleaning and gassing.—Whilst going through all the previous processes the thread has become wild, hairy, and rough, and in many cases shows little nibs which have been caused by the curling and breaking of fibres in the drawing processes, by bad or careless dressing, or by the spinning frame rollers having been allowed to become

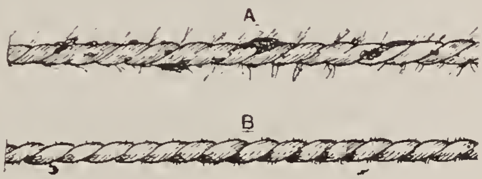


FIG. 104.—Cleaned and not cleaned yarns.

covered with short fibres of silk " fluff," which in time has wrapped itself round the thread. All these faults have now to be removed by means of heat—lighted gas and friction. If the thread has been kept free from fluff, and is the product of a properly dressed and drawn silk, then

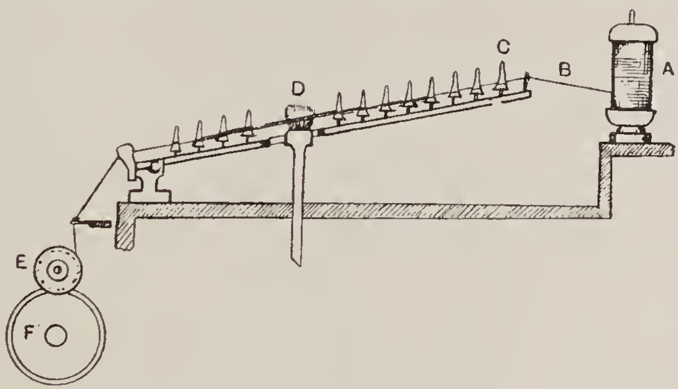


FIG. 105.—Gassing frame.

its defects are chiefly projecting fibres and a general hairiness which can be removed by passing over a gaslight several times. If it contains other faults, then it must be frictioned. An uncleaned yarn is represented in Fig. 104 at A, and a cleaned and perfect yarn at B.

The more free from projecting fibres and rough thick places a silk can be produced, the more valuable it becomes,

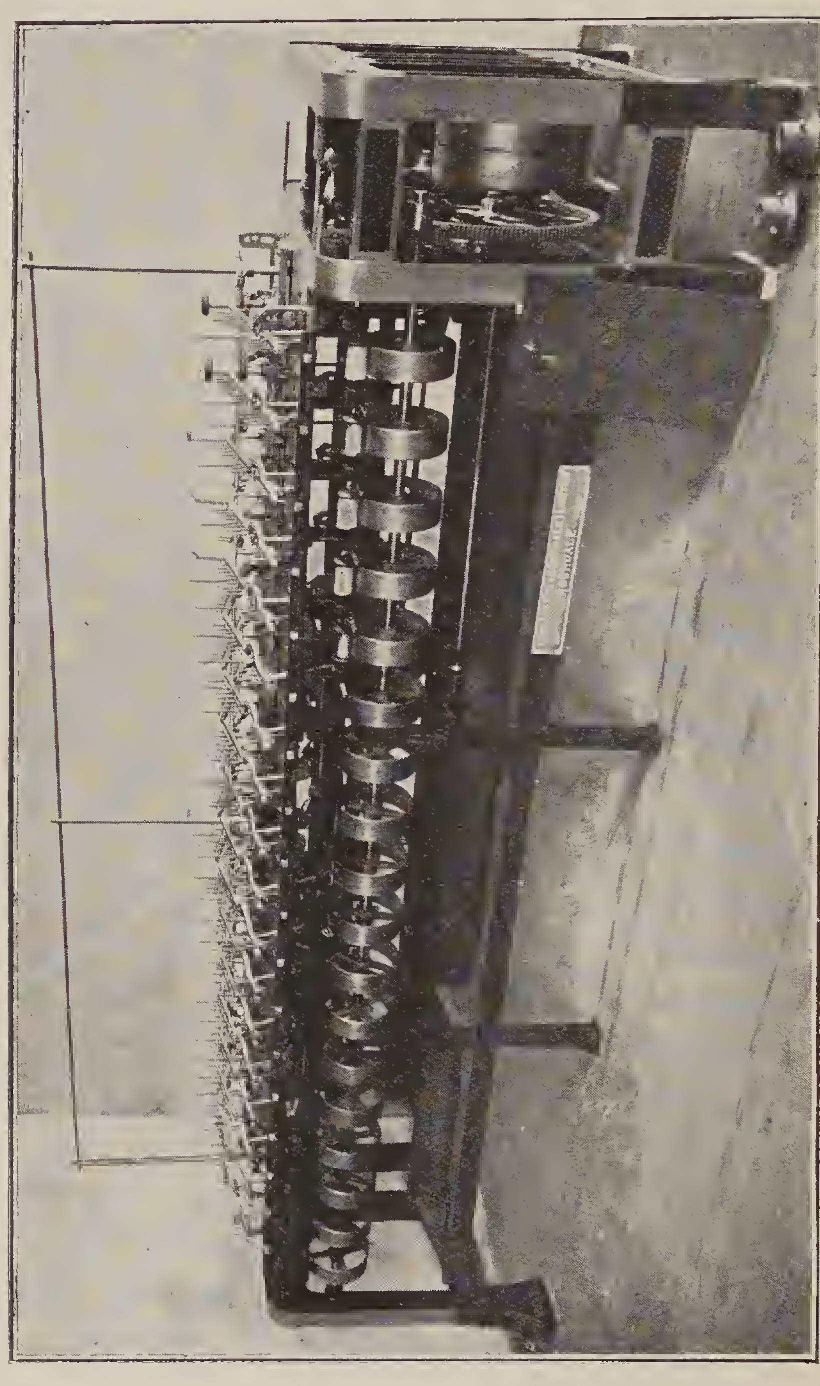


Fig. 106.—Gassing and cleaning machine.

because of its smoothness and consequent lustre. The lustre on silk is peculiar to itself, and can only show to perfection when every pearl of twist is free from fibre. The chief methods of cleaning and gassing are shown in Figs. 105, 106, and 107. In the former, which gives side elevation, A is the bobbin of folded yarn, B the thread of silk which on its passage from A to the receiving bobbin E is wrapped round the cones C, thus passing through the gaslight D. The cones are made of steel, and revolve on pins. If the thread is only hairy, the silk is wrapped half round the cones so as to pass through the gas three to twelve times in one transition of the thread from A to E. But if yarn is nibby as well as hairy, then it is wrapped right round the cone, thus acutely frictioning itself, and so throwing off the nibs at the point of contact. The nibs and fluff travel up the cone, and so away from the thread. The receiving bobbin E is propelled by a drum F. When a thread breaks, the gaslight can be moved away from the position shown, so that the attendant can rewrap the thread on the cones without burning it; and the same action which moves the light lifts the bobbin E off the drum F, thus preventing any unnecessary friction of the silk on the drum. A reverse action takes place when the end is tied up and the bobbin placed on the drum, the light being then put into position again. The lower the quality of silk the more passages through this machine are necessary to cleanse it.

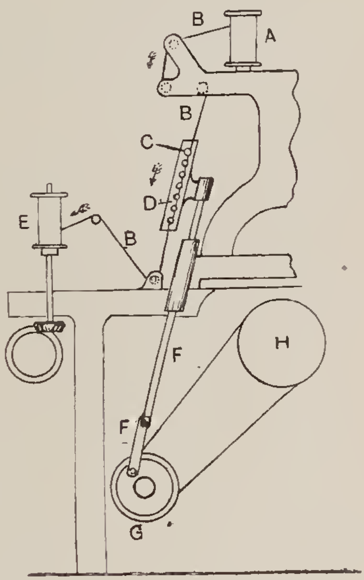


FIG. 107.—Cleaning frame.

Fig. 107 shows a cleaning or frictioning machine, without any gaslight. A represents the bobbin of folded yarn, and B the thread travelling in the direction of the arrows to the receiving bobbin E. The thread is wrapped around the revolving runners C, which are fixed on the rising and falling bar D. During the passage of the thread from A to E the bar D is oscillated up and down by the linked rods F and the crank disc G, which in turn is driven from the cylinder H. Thus the rotary cleaning runners C have a rapid up-and-down motion for the purpose of still further frictioning the thread. If necessary, the yarn can be run over a gassing frame to remove the fibre not taken off by the friction cleaning machine. After cleaning, the silk is ready for reeling or for winding on to large bobbins, from which it is warped.

Reeling and warping.—Schappe silk is reeled on a swift measuring 49 in. diameter, and the usual length of a skein = 500 metres, or 1625 ft. Spun silks are reeled into skeins, and then made up into 5 or 10 lb. bundles in England, or 5 kilos. on the Continent, or they are made into warps in accordance with the requirements of customers. In England the reels are made with swifts of 54 in. diameter, and the yarn is cross reeled in skeins of 840 to 5040 yds. A skein, in the strict sense of the word, is 840 yds. in length. Both reeling and warping are such well-known processes that a detailed description would be useless here, but Fig. 108 illustrates the reel.

Washing.—Many yarns are sold by the spinner in the "grey"—*i.e.* gassed state. In other cases the yarn is washed. If washed in the skein the following is a good method for the treatment of about 50 lb. of silk. The skeins are placed on wood rods, taking care to spread the threads out as open as possible, as at A in Fig. 109. These rods of silk are then taken to the washhouse and placed in a wood vat B containing 40 gallons of hot water, into which about 6 lb. of best white oil soap has been dissolved.

It is wise to see that the water is not boiling when the silk is just placed in the vat, or the yellow stain caused by gassing the yarn will be burnt or boiled into the silk. An attendant is required on each side of the vat, and when

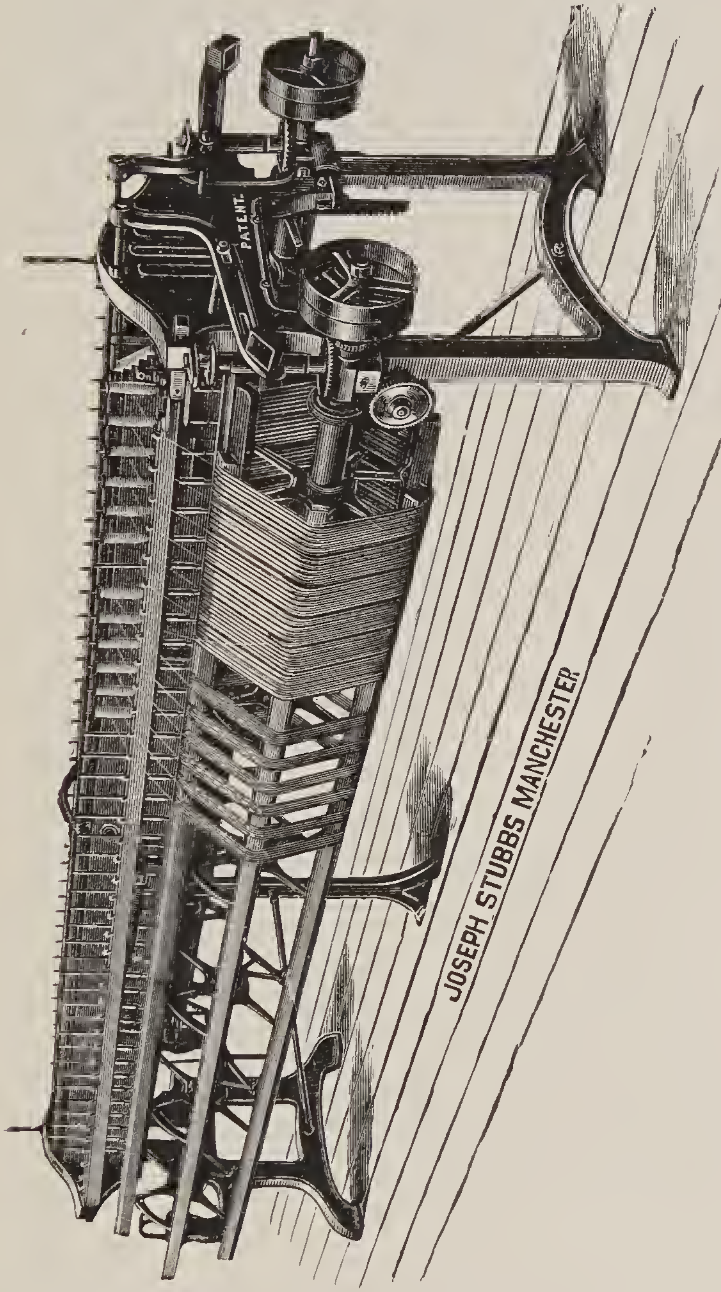


Fig. 108.—Bobbin reel.

the silk has become thoroughly saturated with the soapy liquor, the rods are lifted up and down (positions U and

D) many times, first dropping the silk into and then lifting it out of the water. The end C having become partially cleansed, the attendants turn this on the rod so that the hitherto unwashed portion of the skein E is in the water, and then the lifting and lowering motions are again gone through. The attendants take care all the time that the threads keep straight, untangled, and free from breakages, and after about thirty minutes of these constant turnings the rods are placed close together at one end of the vat, and the silk laid on the top of the rods to allow the liquor to drip out. When this has been effected the silk is taken to a fresh vat with clean water and soap, and the processes

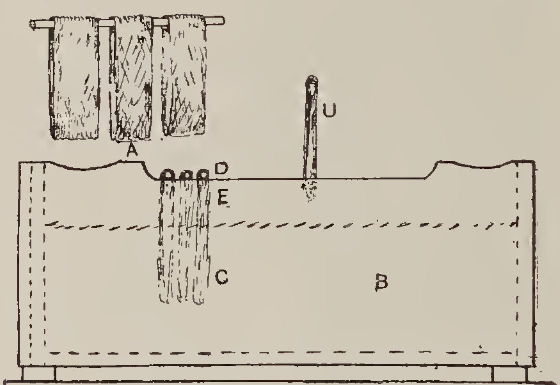


Fig. 109.—Yarn washing.

repeated; but in this case the water can be boiled if it is desired to swell the thread and make it bulky. After this the water is wrung out of the skeins either by hand or hydro extractor. The yarn is then taken to a stove and hung on rods to dry, and when dry is ready for conditioning. Taken straight from the stove it feels harsh and stiff, and is lustreless; but after being placed in a cool, damp room for a few hours, it regains its softness, pliability, and lustre, and is ready for bundling up and delivering to customers. Usually only lace yarns and hosiery yarns are washed, most other yarns being delivered in hank or warp to the dyehouse for dyeing, the dyer generally washing the yarn off before dyeing. Fig. 110 shows operatives engaged in washing.

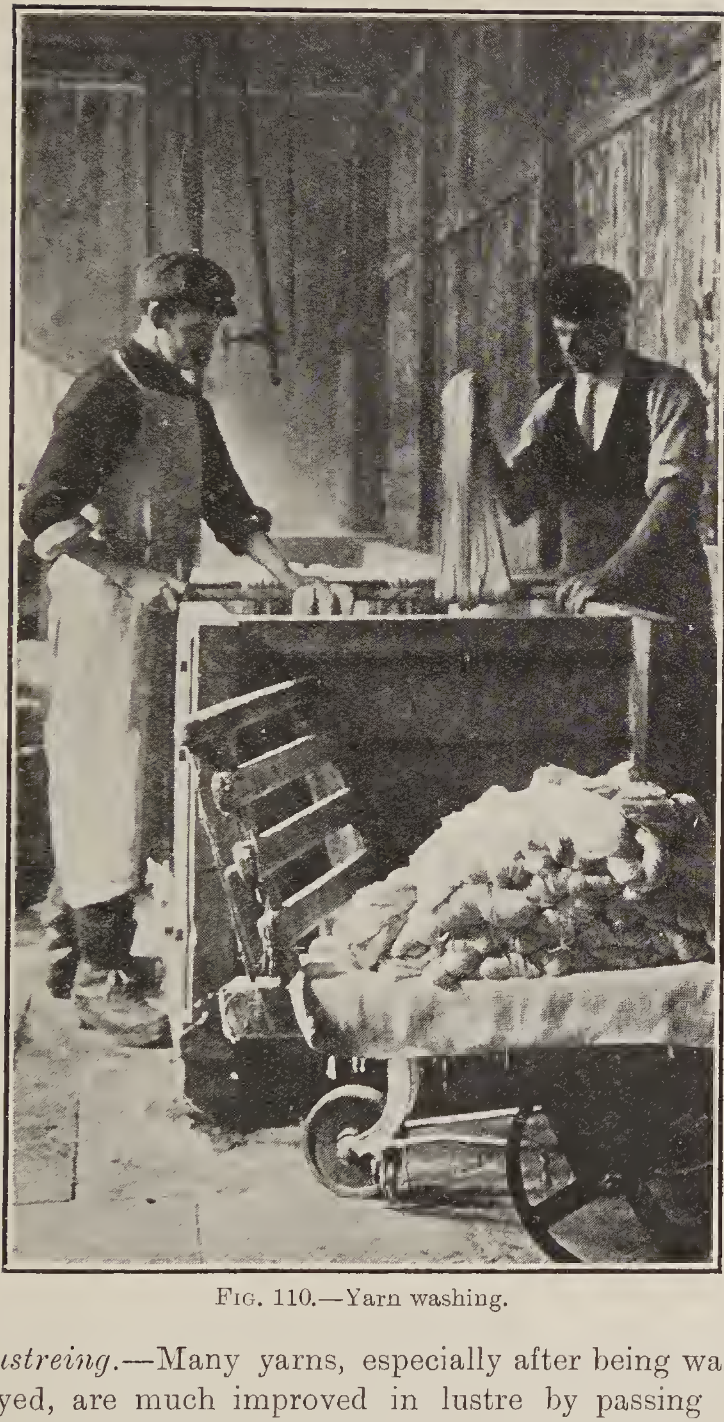


Fig. 110.—Yarn washing.

Lustreing.—Many yarns, especially after being washed or dyed, are much improved in lustre by passing over the machine (illustrated by Fig. 111). This machine is

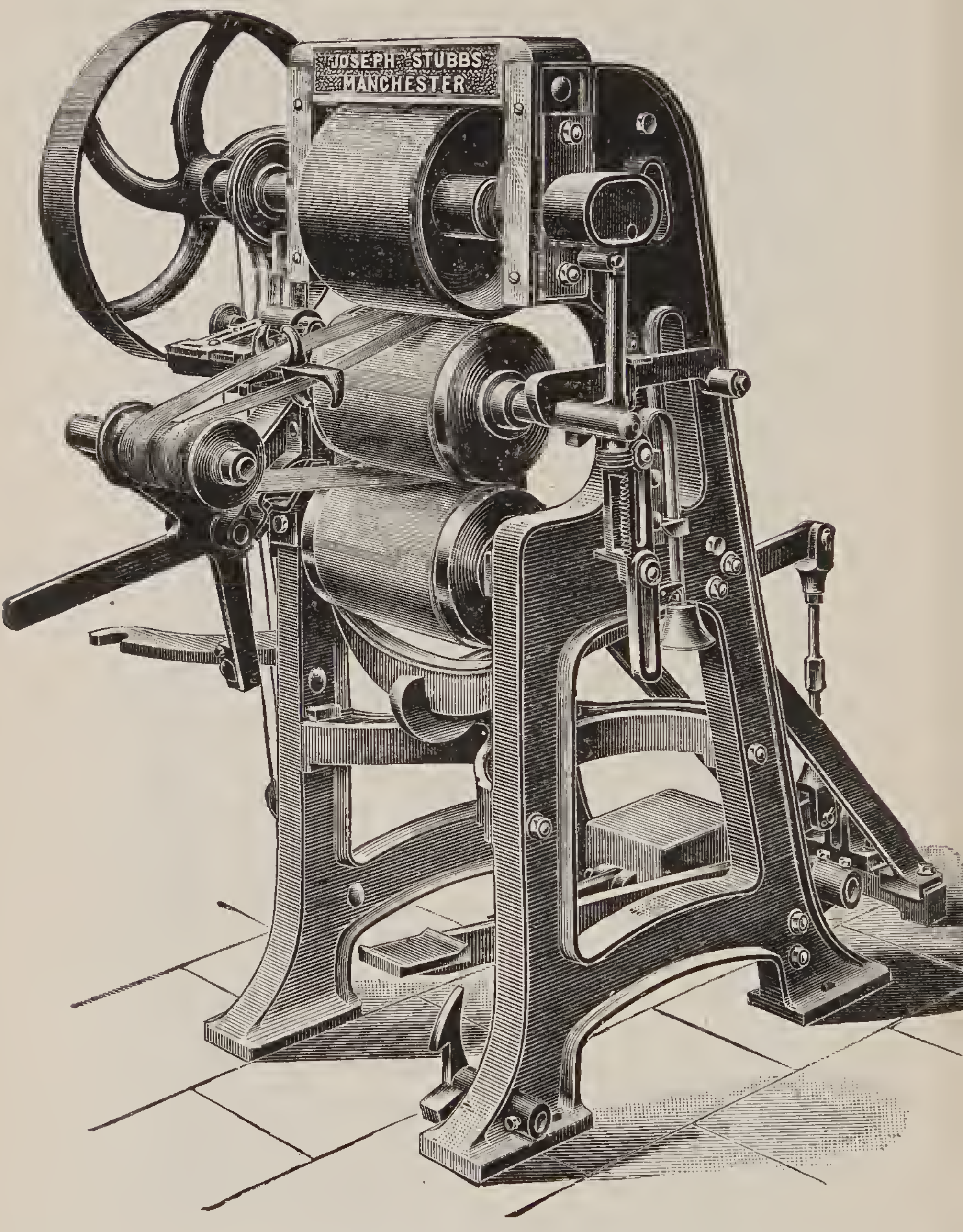


Fig. 111.—Improved yarn preparing machine.

constructed to lustre yarns in the hank, which it performs very effectually by stretching the hank from centre roller to small roller whilst the top and bottom rollers revolve the hank round and round so that all portions of the thread are properly frictioned.

English counts.—The English counts or size of spun silks are calculated as follows: 840 yds. weighing 1 lb. would be 1's, then counts 120's would equal 120 skeins per pound, each skein of 840 yds. length. If the thread consists of two or three strands—*i.e.* two-fold or three-fold—the count is still the number of 840 yds. per pound; thus counts 60's of two-fold yarn, expressed 60/2, means 60 hanks of 840 yds. per 1 lb., and represents in the single-thread, size 1/120's. The only exception to this rule is in the case of three-fold hosiery; for instance, a three-fold 40's hosiery yarn is spun 60's single, equalling in ordinary silk counts three-fold 20's.

The following examples in tabular form show the system more clearly:—

Single Yarns.		2-fold Yarns.			3-fold Yarns.			3-fold Hosiery Yarns.		
No. of 840-yard Skeins per Pound.	Yarn Count Expressed.	No. of 840-yard Skeins per Pound.	Folded Count Expressed.	Spinning Count.	No. of 840-yard Skeins per Pound.	Folded Count Expressed.	Spinning Count.	No. of 840-yard. Skeins per Pound.	Folded Count Expressed	Spinning Count.
12	1/12's	6	6/2-fold	1/12's	4	4/3-fold	1/12's	4	8/3-fold	1/12's
30	1/30's	15	15/2 ,,	1/30's	10	10/3 ,,	1/30's	10	20/3 ,,	1/30's
60	1/60's	30	30/2 ,,	1/60's	20	20/3 ,,	1/60's	20	40/3 ,,	1/60's
120	1/120's	60	60/2 ,,	1/120's	40	40/3 ,,	1/120's	40	80/3 ,,	1/120's

TABLES OF TWISTS.—The next series of tables show the approximate amount of turns per inch in singles and folded yarns for various purposes, assuming that the yarn is of good quality, *i.e.* long drafts. If a poorer quality yarn is required, the turns per inch would need hardening, especially in the single thread of the two-fold weft table.

All the twists, excepting the three-fold sewing-thread yarns, are made with what is commonly termed "right twist." That is, the turns per inch are to the *right* in the folded yarn, and to the *left* in the single thread. The sewing threads are opposite to this—namely, LEFT in the folded yarn and RIGHT in the single thread. These differences can easily be seen by holding a strand of yarn between the hands, and noticing in which direction the perle of twist appears to point.

Singles for Weft.		2-folds for Weft.			2-folds for Warp.			2-folds for Plush.		
Counts.	Turns per Inch.	Counts.	Turns per Inch. Single.	Turns per Inch. Folding.	Counts.	Turns per Inch. Single.	Turns per Inch. Folding.	Counts.	Turns per Inch. Single.	Turns per Inch. Folding.
1/40's	6	30/2-fold	12	10	30/2-fold	15	14	35/2-fold	19	17
1/50's	6¾	40/2 ,,	13	11	40/2 ,,	17	16	40/2 ,,	20	18
1/60's	7½	50/2 ,,	14½	12	50/2 ,,	19	18	45/2 ,,	21¼	19
1/70's	8¼	60/2 ,,	16	14	60/2 ,,	21	20	50/2 ,,	22½	20
1/80's	9	80/2 ,,	19	17	80/2 ,,	24	23	...	...	...
1/100's	10	100/2 ,,	21	19	100/2 ,,	28	26	...	...	...

2-folds for Flannel, Silks, and Embroidery.			3-folds for Hosiery.			3-folds for Sewing Cords.		
Counts.	Turns per Inch. Single.	Turns per Inch. Folding.	Counts.	Turns per Inch. Single.	Turns per Inch. Folding.	Counts.	Turns per Inch. Single.	Turns per Inch. Folding.
2½/2-fold	6½	6½	...	...	...	6/3-fold	12	8
4/2 ,,	9	9	...	...	...	8/3 ,,	14	10
6/2 ,,	11	11	...	...	...	10/3 ,,	15½	10½
8/2 ,,	12	12	30/3-fold	11	3	12/3 ,,	18	12½
10/2 ,,	14	14	36/3 ,,	12	3¼	14/3 ,,	19	13
12/2 ,,	16	16	40/3 ,,	13	3½	16/3 ,,	21	14
...	...	...	44/3 ,,	13½	3¾	18/3 ,,	22	15
...	...	...	50/3 ,,	14	4	20/3 ,,	23	16
...	...	...	60/3 ,,	15	4½	22/3 ,,	24½	16½
...	...	...	80/3 ,,	19	5	24/3 ,,	25½	17
...	...	...	...	...	...	26/3 ,,	27	18
...	...	...	...	...	...	28/3 ,,	28	19
...	...	...	...	...	...	30/3 ,,	29	20

SCHAPPE COUNTS.—The yarn count of schappé (continental spun) silks expresses the number of 500 metre hanks to the half-kilogramme (1·1 lb. English).

CHAPTER XI.

UTILISATION OF WASTE PRODUCTS.

HAVING particularised all the processes through which dressed silk, long drafts and short drafts, are passed to convert into yarn, we have now only to follow the course of the waste products of a silk spinning establishment. These are: silk noils, the production of the dressing frame; fly, the very short fibres thrown out in the cards; roller and leather laps in the drawing machinery; roving waste in the roving frames; soft waste in the spinning frames; singles and double waste in winding and twisting; burnt fibre in the gassing process.

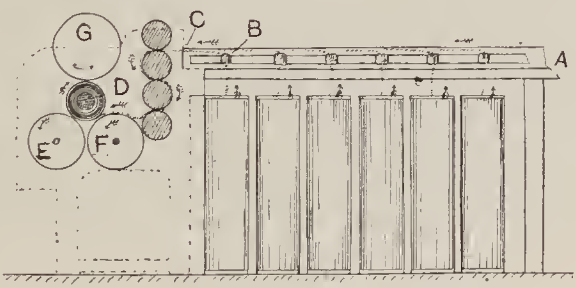


FIG. 112.—Derby doubler (section).

Burnt fibre is sold as waste, and used for artificial manure purposes.

Roving waste and soft spinning waste can be washed to free it from grease and dirt, and be then dressed or carded and combed, so converting it again into drafts or sliver and noils.

Hard single and folded waste can be dressed on hand machines, or put through a garnet machine and then carded and combed.

The longest kind of roller and leather lap waste can be fed into the spreading machine, converted into sliver, and mixed with the lowest quality going through the machinery, putting one or two ends up in the first head of the drawing. The short fibre can be mixed with roving waste and dressed or combed.

The longest-fibred fly waste is recarded, thus being made into a sliver and mixed in the drawing frames. The shortest-fibred fly can be put through the same machinery as exhaust noil.

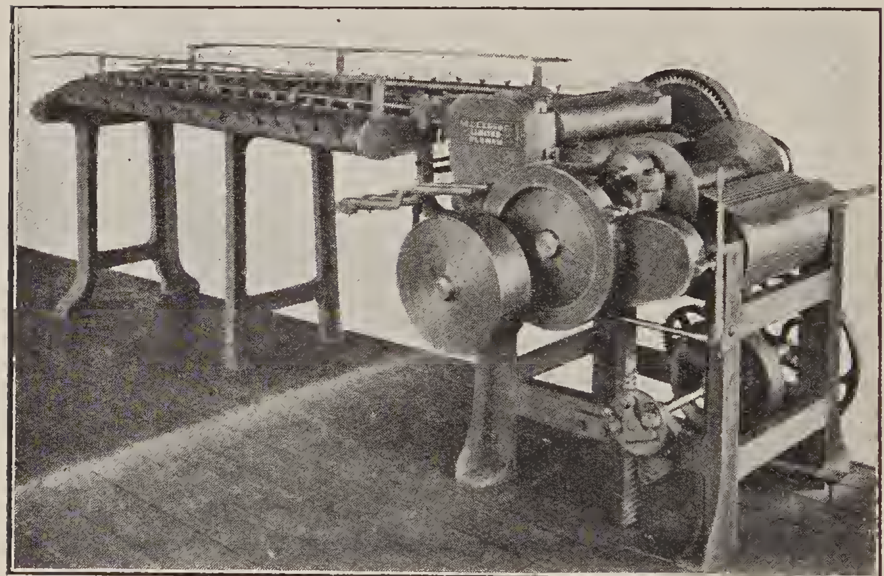


FIG. 113.—Derby doubler.

Noil treatment.—Noils are first opened by a scutching machine and then carded. The carded slivers are afterwards taken to a Derby doubler.

Derby doubling.—This process is carried out for the purpose of winding a certain number of carded slivers together on to a wooden core or drum. From twelve to eighty cans of sliver can be placed side by side on either side of a slanting table A, Figs. 112 and 113, and the sliver is passed over the spoon levers B, thence through the guide plates C to the wooden drum D. This latter is revolved by means of fluted rollers E, F, and the slivers all wound into one mass called a lap, and compressed by the pressure roller G, which, being mounted in slot bearings, rises as the slivers on the drum D increase in diameter. If a can becomes empty or an end breaks between the can and the receiving rollers, the spoon lever is arranged to drop and automatically stop the machine, so ensuring an equal number of ends of sliver throughout the length of the lap. The laps are next mounted behind

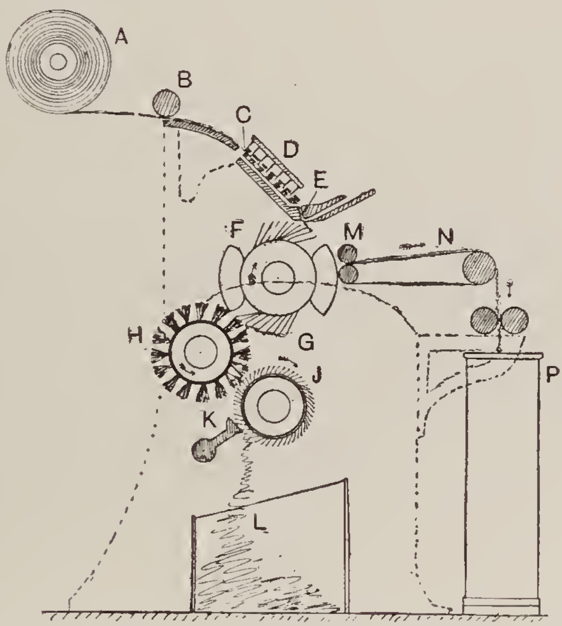


FIG. 114.—Combing (section).

a combing machine, which may be of the Noble, Lister, or Heilmann type.

Combing.—A comb is for the purpose of removing from the silk all nops, dirt, straws, for eliminating fibres below a predetermined length, and delivering the combed material in the form of a sliver. The Heilmann principle is a very good one for silk fibres, and is illustrated in Figs. 114 and 115. The lap is placed at A, and is revolved slowly by rollers under it, the sliver passing to the pressure roller B and thence to the feed grid C. This latter consists of two smooth brass grids into which fit the pins of the overhead comb D. When the nip E is closed, the feed comb D being lifted, the grid moves back for a portion of sliver; then the comb D descends, penetrating the sliver. Then, the lower hinge of the nip being opened, the silk is traversed through the mouth of the nip, which closes and so holds fast a tuft of silk, projecting so that the teeth of the comb F on the comb revolving can comb or dress the fibres. The short fibres (exhaust noils) G which collect on the teeth of the comb are removed by a quickly revolving

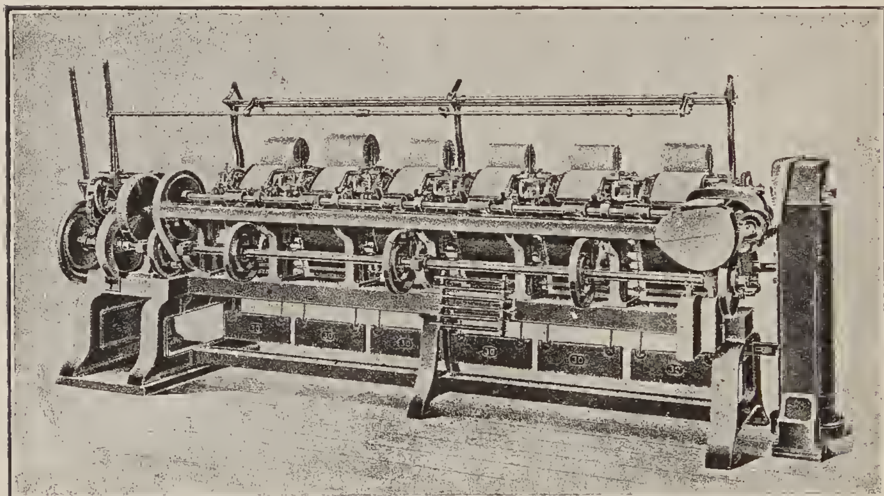


FIG. 115.—Improved combing machine (Heilmann system).

brush H, which deposits the combings on to a doffer roller J, from which they are stripped as a broad fleece by the doffer comb K and drop into the box L. When the tuft of silk is sufficiently combed the rollers M are operated in such a manner as to lay hold of the combed portion, and so draw the other, or uncombed, end of the tuft through the revolving teeth of the cylinder, which clears the silk, as described, for the first end. The combed tuft is delivered to the creeper N, formed into a sliver, and delivered to the can P.

The proportion of combed sliver to combings (exhaust noil) can be varied by adjusting the closeness of comb to nip, so that all fibres below $\frac{2}{3}$, $1\frac{2}{3}$, etc., of an inch, pass into noils. The more fibre taken out, the cleaner the resulting combed sliver and the greater the production of noil. The combed sliver is used by short spinners, being either made into a combed yarn, or more often a certain number of the slivers are put in the drawings and so amalgamated with some other carded quality of shorts.

Exhaust noil spinning—Garnetting.—Exhaust noils are made into coarse yarns on the woollen principle. The first process is designed to open or loosen the silk, and is much the same as scutching. Next, the silk is carded or garnetted on the machine shown in Fig 116. It is fed by hand to the feed-box A, then carried up the pin-studded

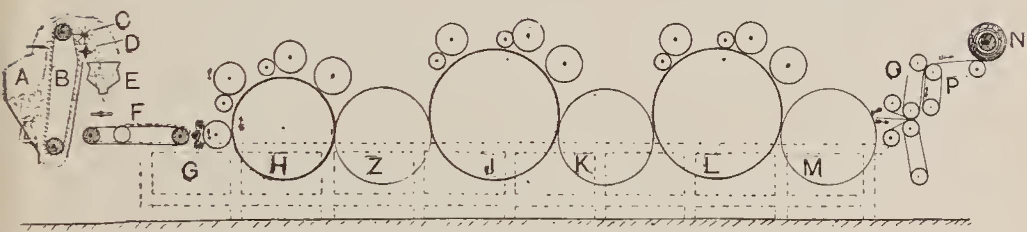


FIG. 116.—Garnetting machine.

creeper B in a certain regular quantity, and delivered by means of the rollers C and D to the weigh-box E, which opens automatically when it has received a predetermined weight of silk. It drops the silk on to the feeder F, which delivers to the taker-in rollers G, which in turn take it to the breaker card H. The doffer cylinder Z transfers the carded silk to the intermediate cylinder J and doffer K, which in turn delivers to the finisher card L and doffer M, and thence to the condenser bobbin N. The object of condensing is to convert the full-width fleece of silk on the cylinder L into a number of thin, loose slivers. One or two doffer cylinders M (one only is shown) are used to strip the swift L. These are covered with card rings an inch wide, with an inch blank space between each card ring, the blank of the top roller being above the card of the bottom roller, thus ensuring an entire stripping of the surface of the swift. The ends on the strips of card on the doffer M are then conveyed to the rubbing leathers O, P. These are endless leather belts carrying forward the thin ribbon of silk between them, but at the same time a sidewise motion is imparted which rubs the silk into a loose, round, pith-like roving without any twist in it. On leaving the leathers, the ends are conveyed to the bobbin N, on to which they are wound ready for spinning.

Mule spinning.—The condenser bobbins are placed behind the machine shown in Fig. 117, and the ends of silk conveyed to the rollers B. These rollers correspond

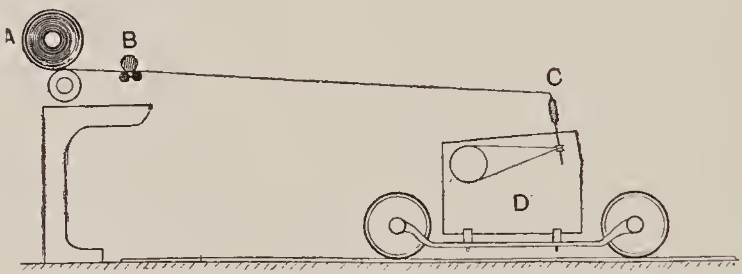


FIG. 117.—Mule spinning.

to the back rollers of the spinning machines previously described, for they do not draft the roving. The roving being delivered by the rollers B, is wrapped round the spindles C fixed in the carriage D. This carriage is close up to the rollers at the commencement of the draw; but as soon as the rollers revolve, delivering roving, the carriage traverses away from the rollers at such a speed as to keep the roving stretched, but without drafting it. The spindles are meantime turning slowly, thus putting a little twist in the roving. When the carriage has gone half its journey, the rollers B cease to revolve, but the carriage travels on, thus stretching out the roving from 1 yd. to 2 yds. in length; while, as the spindles are still revolving more twist is still going into the thread. When the carriage stops, the spindles revolve still more quickly until

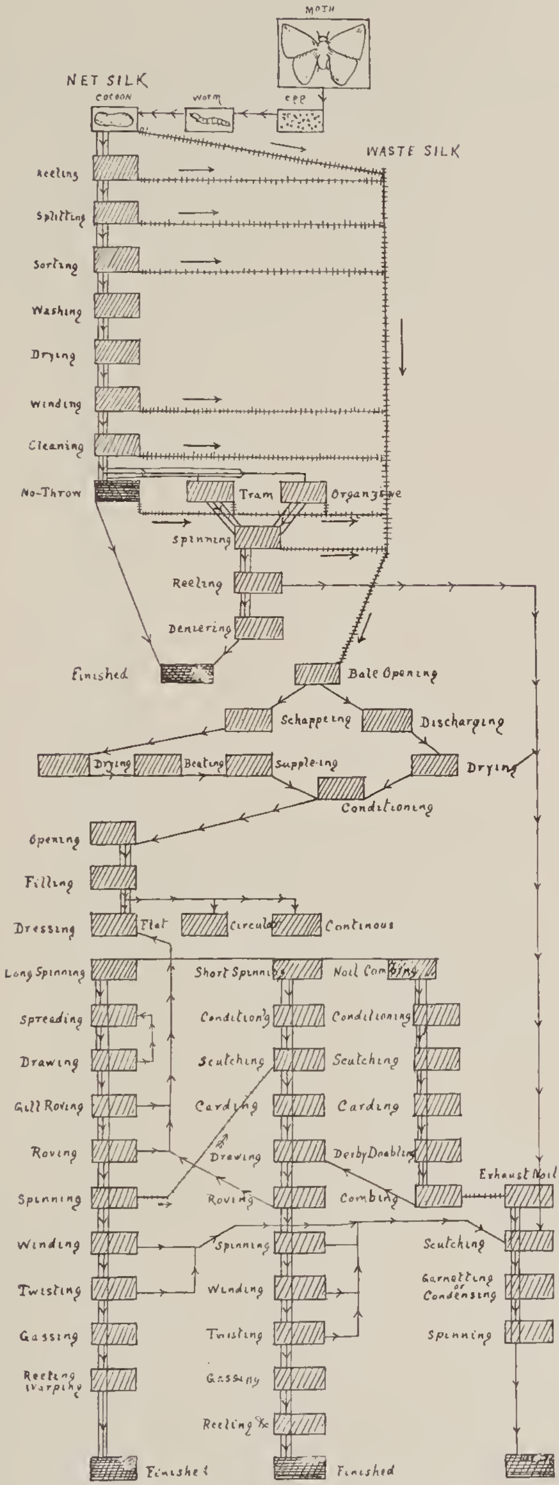


FIG. 118.—Diagram of all processes.

sufficient twist is put into the yarn, and the carriage is then traversed back to the rollers, while the spun thread is wound on to the spindles during this backward journey.

The count of the yarn is regulated chiefly by the size of the rovings delivered by the condenser, which in turn is regulated by the amount fed into the cards at the commencment. After spinning, the silk noil yarn is often sold in the singles, but if required two-fold it can be doubled on any class of doubling or twisting machinery.

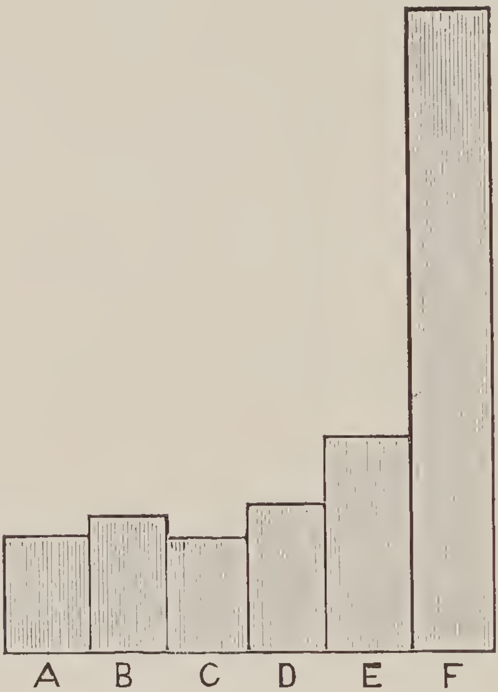


FIG. 119.—Waste silk. World consumption.

In conclusion, a summary of the various processes is given diagrammatically in Fig. 118, by which it will be possible at a glance to trace the fibre from the silk moth to the finished yarns of the throwster and waste spinner, and the lines to the right in each operation show to what purpose is placed the waste products of that operation. Arrow heads indicate the proper directions to follow each line of waste products.

The above and following diagrams give the position of the silk waste trade up to 1917, and comparisons with other countries : Fig. 119, the world's consumption of waste silk exclusive of Japan for year 1911 was 36,700,000 lb.

Column A represents consumption of U.S.A.
,, B ,, ,, ,, England.
,, C ,, ,, ,, Italy.
,, D ,, ,, ,, France.
,, E ,, ,, ,, Switzerland.
,, F ,, ,, ,, The World.

Fig. 120 represents importations by U.S.A. of spun

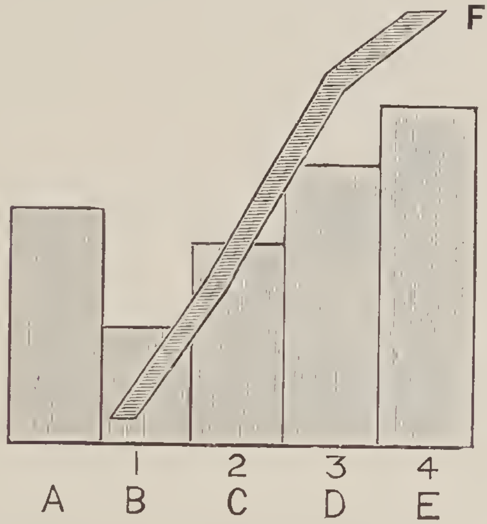


FIG. 120.—Waste silk. Spun yarn importation, U.S.A.

yarns. The columns proportions of nations, *viz.*, A from Japan, B England, C Italy, D France, E Switzerland.

The inset line F shows total imports 2,490,846 lb. for year 1918, increasing from 197,139 lb. in year 1888, the rate of increase being shown in ten year periods, *viz.*, 1888 in column 1, 1898 in column 2, 1908 in column 3, and 1918 in column 4.

Fig. 121 shows importations of waste silk into England. Column A represents 3,724,000 lb., years 1871-79, the high-water mark being reached in years 1905-15 shown at column B. Columns C, D, E are respectively years 1916, 1917, 1918, the latter year's figure being 5,362,112 lb.

Fig. 121.—Waste silk.

Line F shows U.S.A. importations for year 1915, being 3,800,000 lb., and reaching 9,303,126 lb. in year 1918 shown over column E.

The End.

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